First Report

ON

THE GEOLOGY AND MINERAL RESOURCES OF BRITISH SOMALILAND.

(WITH MAP.)

BY

R. A. FARQUHARSON, M.A. (Oxon.), M.Sc., F.G.S., A.O.S.M.
Government Geologist.

PRINTED BY
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1924.

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Geology

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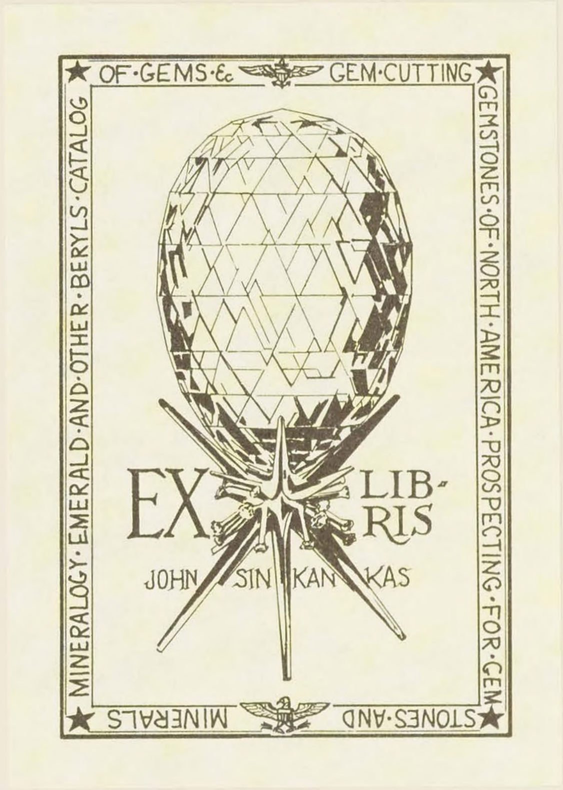

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I.—INTRODUCTION.

From time to time since 1901, specimens of minerals obtained in the Protectorate by British officials, either from Somalis or as the result of information given by natives, had been sent by the Administration for examination to the Imperial Institute, London, and, as the reports on the analyses of these specimens indicated that some of them were of economic value, it was considered important by the Governor not only that the individual occurrences should be authenticated by an expert, but that a general investigation should be made of the prospects of different parts of the country with reference to its mineral resources, and that, if possible, other minerals of value should be discovered. Accordingly, it was suggested by the Governor to the Colonial Office that the services of a highly qualified Geologist should be obtained in order that this work should be carried out. Towards the end of 1922 the present writer was appointed to the position created.

According to the official files, the appointment of the Geologist was " for one year in the first instance, because he should be able to get a good idea of the prospects in one year, and if they were promising, possibly (the Colonial Office would) arrange for an extension."

The scope of the investigation was to some extent laid down in a letter from the Lords Commissioners of His Majesty's Treasury, dated April 27th, 1921, in which it is stated that " it would appear to be desirable that investigations should be directed for the present to the areas which would be accessible for commercial operations."

Owing to the nature of the topography of the Protectorate, this expression of opinion, undoubtedly based on common sense and a knowledge of all the conditions—of transport, of population, of communications, and of the political situation—obtaining in the country, restricted the geological work to areas lying north of a line drawn from Somadu in the west, through Boramo, Hargeisa and Sheikh to the Eastern boundary at the bottom of the escarpment south-east of Las Gori.

The writer arrived in Aden on January 31st, 1923, and in Berbera on February 5th, and left Berbera en route for London on February 11th, 1924. Practically the whole of the intervening period was spent in trekking and geological surveying and matters directly connected with one or the other.

During the first two weeks, a search was made of all the files dealing with the occurrence of minerals and water supplies in the Protectorate, all available information was collected, and the whole of the necessary equipment, instruments, stores, etc., assembled. It was originally intended that Berbera should be made a headquarters and that trips should be made from it to each district in turn. As a brief consideration, however, of the topography of the country showed that by adopting this scheme it would be necessary to traverse repeatedly the coastal plain and considerable tracts almost devoid of water and feed and of no value whatever so far as a mineral survey was concerned, this intention was abandoned, and it was decided that, in order that the maximum amount of ground should be covered in the least time and the most comprehensive examination of the country possible in the time should be made, anything but a nominal headquarters should be dispensed with, that arrangements should be made for repairs, rationing of men and animals, re-engagement and payment of camel men and coolies and all official correspondence and accountancy to be done either on trek or, if convenient, on arrival at a hill station.

On account of the political situation, it was decided by the Governor that the Gadabursi district of Western Somaliland should be examined first and that the work should begin from Zeyla. At His Excellency's request, a programme for the year's work was submitted to him, and it was approved subject to a recommendation that,

in the interests of health and comfort, the traverse of the country from Las Gori to the Italian frontier and back through Hais to Berbera, proposed for August and September, should not be undertaken until towards the end of the year.

By these arrangements, it was possible to examine, during the hot season of the Kharif wind, those areas of high elevation least affected by it, and to a large extent to leave the low-lying " Guban "† country until the cool season, though, as it turned out, owing to the fact that the work could not be begun before the end of February, nearly two months' experience of the heat and humidity of the hot season had to be undergone in order that an investigation could be made of the country between Sheikh and Ankor, and between Ankor and Bihendula.

As, particularly in Western Somaliland, it was known that the existing maps were very incomplete and to a large extent inaccurate, as many wells, pools and "durdurs"* were not shown, as many names on the map signified nothing on the ground, as no permanent villages existed and there were few named peaks on the maps as distinct from ranges or ridges, and as even the main tracks in use were only partly or not at all mapped, it was advisable that data should be obtained for the preparation of a fairly reliable topographical map on which not only these important features, but the locality of any mineral occurrences could be set out. To this end, a careful prismatic compass and plane-table traverse was made of all the routes followed‡ on a scale of four miles to one inch. It had also been intended, as no triangulation of the district had ever been made, to check the traverse from time to time by observations for latitude, and for this purpose, a theodolite was ordered from Berbera. Unfortunately, an inspection of it at Zeyla showed that, not only was it hopelessly out of adjustment, but that essential parts were either missing or did not fit the instrument, so that this method of check was not practicable. The traverse, however, was started from Somadu, the position of which had been previously fixed by Major Craster, R.E., and carried on to Boramo. At Boramo, on the allowable assumption that the position of Jifa Medir and of Jifa Uri on the Abyssinian border were fairly correct, bearings were taken from the top of Sher Laga Mahdi, 6,200 feet high, to these two peaks and to all the more important peaks of the Gadabursi district, and these bearings were used to check the traverse from Boramo through the district. Other check-bearings made use of were that from Hemal to the summit of Manda Hill, the position of which was fixed by Major Craster, and the closing bearing on Gibele Police Station on the Hargeisa-Boramo track.

The routes followed are shown in the accompanying plan. Exclusive of the sea-trip from Berbera to Las Gori, the trip to Kirrit and back to Berbera, which was accomplished by motor-truck, and the distance travelled in the ascent of hills and ranges and in examining the country on each side of the track and in the neighbourhood of each camp, the total distance covered on pony, on mule, on foot and with camel or donkey transport was 2,066 miles.

The general geology of the country, the locality of each of the mineral occurrences, and the position of those areas which show sufficient promise to justify further systematic prospecting, are shown on the accompanying plans§.

In view of the existing differences of opinion with regard to the age of the various limestones in the Protectorate, as opportunity offered, collections were made of the fossils obtainable on the track and near each camp. Altogether, forty-eight separate collections were made, and these, by arrangement through the Colonial Office, are now being examined at the Natural History Museum. Moreover, a typical collection was made of the chief rocks met with on the whole tour. An accurate detailed account, therefore, of the geology of the country will only be possible when these fossils and rock specimens have been determined; but it is hoped that, when these results are available, an opportunity may be afforded of writing up the more strictly scientific results of the investigation, especially as the outcome of the recent work is ultimately of more than mere local significance, and the scientific, as distinguished from the economic results, have ultimately an important bearing on the latter.

Numerous photographs were taken on the various treks of the chief features of topographical and geological interest met with.

The survey party contained, besides the writer, five armed police, an interpreter, one or two guides who were usually head-men of tribes, personal servants, sixteen camel-men and camels for the transport of equipment and rations, and a pony and mules.

The writer wishes to take this opportunity of acknowledging the cordial assistance given him on all occasions by the officials of the Protectorate. To the District Commissioners and police officers he has been especially indebted, as, to the arrangements

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† See later.
* Streams which rise in a tug, flow for a short distance along it and then disappear beneath the sand.
‡ In the Gadabursi district.
§ See footnote to Contents.

made by the former for the cordiality and assistance of the tribes and by the latter for the peaceful conduct of the party and the peaceful relations between it and the natives met with all over the country, is to a large extent to be attributed the fact that the work has been carried out without a hitch from start to finish.

To Mr. O'Byrne, Chief of Customs, also, special acknowledgment is due, not only because his collection of Somaliland minerals, amassed during more than twenty years' residence in the Protectorate, gave useful clues as to the nature of the various minerals that exist in the country, but because it is largely owing to his long-continued interest in its mineralogy that sufficient information was at length obtained to render it advisable that a mineral survey should be made.

Finally, the writer desires to place on record the zeal, loyalty and intelligence displayed—frequently under very difficult conditions—by the native members of his party, and particularly by those in the pay of the Government.

II.—GENERAL GEOLOGY.

Several articles have been published from time to time during the last 25 years dealing with some aspects of the geology of Somaliland, and those that the writer has been able to gain access to are contained in the following list. The list, however, cannot be regarded as exhaustive:—

1. An article by Miss C. A. Raisin, *Geological Magazine*, 1888, p. 414, briefly descriptive of the country from Zeyla to Mount Eilo, and that at a distance of abcut fourteen miles south of Bulhar, and containing an account of some rocks, metamorphic, sedimentary and igneous, obtained from these parts of the Protectorate.

2. An article by Prof. J. W. Gregory, *Geological Magazine*, 1896, pp. 289-296, giving an account, with a section, of the geology of the central area from Berbera southwards to the top of the Golis Range, and containing a discussion on the age of the limestones.

3. Another article by Prof. J. W. Gregory, *Geological Magazine*, pp. 26-45, giving additional information about the geology and palæontology of the Central District.

4. Notes by Miss C. A. Raisin, *Geological Magazine*, 1903, on rocks obtained during a trek from Berbera through Harrar into Southern Abyssinia.

5. An article by R. B. Newton, *Quart. Journ. Geol. Soc.*, Vol. lxi., p. 155, on Tertiary Fossils of Somaliland.

6. A resumé of the Geology of Somaliland, in "The Geology of the British Empire," by Read.

7. A Report on the Daga Shabell Oilfield (British Somaliland) by Mr. Beeby-Thompson and Dr. Ball.

8. Report on the Geology of British Somaliland, by Drs. Wyllie and Smellie, of the Anglo-Persian Oil Company (with special reference to the occurrence of petroleum in the Protectorate).

A full account of the geology (including the physiography) of the Protectorate cannot be given until the examination of the numerous rock specimens and fossils collected by the writer has been completed; but as it is considered that the general conclusions arrived at as the result of the field work are on the whole fairly correct, the following brief account may be given here:—

(A)—PHYSIOGRAPHY.

Broadly considered, there are four chief elements in the physiography of the Protectorate:—

(*a*) The Coastal Plain.

(*b*) The so-called Maritime Mountains and Inland Plain.

(*c*) The main scarp together with, as its eastern and western prolongations, the series of mountain ranges and ridges; these form the chief watershed and the most elevated portion of the country.

(*d*) The rolling plains on the southern side of the main watershed, which, broken here and there by isolated ridges, extend for many miles into Abyssinian territory.

(*a*) The Coastal Plain.

This consists of a nearly flat, barren and almost treeless strip extending from the western to the eastern frontier for varying distances from the shore. South of Zeyla in the west, the strip is at least sixty miles wide; south of Harag Jig, its width narrows to about thirty miles and, from this point to the vicinity of Berbera, it becomes progressively narrower until, behind Berbera, it extends for only seven miles to the first of the Maritime ridges. From Berbera eastwards it is in several places interrupted by limestone and gneissic ridges, which extend to the coast, and, though in places it scarcely exists at all, and in others, as behind Karam, Ankor, Raguda, widens out to several miles, in general it may be said to become gradually narrower until, near Las Gori, it is only a few hundred yards wide.

The plain is composed near the shore-line in part of beach sand, but largely of an alluvium of quartz and felspar sand intermixed with pebbles of granite, gneiss, epidiorite and limestone brought down by the tugs from the high levels. Round Berbera, and especially at Ankor and Wagderia, it is composed, for some hundreds of yards back from the shore, of coral limestone. The present height of this limestone and the fact that at Wagderia and around Berbera and south of Elaiya occur banks of oyster shells and other recent fossils, afford interesting evidence that the coast line, at least of the central and eastern parts of Somaliland, has been rising for a considerable length of time.

There is a gradual rise in the level of the plain from west to east southwards towards the Maritime ridges, the Dubar springs on the southern edge of plain seven miles from the coast, being about 400 feet above sea level. No streams or rivers flow over it except that, occasionally after continuous heavy rain on the main escarpment, sufficient water flows in the tugs for some to escape being absorbed by the sandy alluvium and to persist to the coast. There is, however, evidence that a considerable amount of water is flowing underground to the sea, probably along very old water channels (*see* Water Resources below).

The plain, where not treeless, is covered in patches by low thorny khansa bushes, though, owing to the fact that the largest of these were formerly cut down by the Somalis, those that at present exist are being gradually choked by the sand.

(*b*) The Maritime Mountains and the Inland Plain.

These constitute the tract of hilly country which stretches from the foot of the main watershed northwards to the edge of the Coastal Plain. In reality, they consist of a plain on which are scattered numerous small steep isolated and fragmentary escarpments and hills. The division may be said to begin with the western ends of the ridges of Bur Ad and those near Hemal in Western Somaliland, and to extend eastwards as far as the west-facing scarps of Siradli and Surad Ad south of Hais. It comprises the tract lying north of Sigip and Wobleh Ranges, north of Hargeisa, and north of the Golis Range, Wagger Range, Ashararet Range and the Sugali scarp. The numerous ridges and hills comprising it consist in part of fault blocks of Jurassic limestone and of Eocene limestone and Dubar Sandstone, with scarps facing in all directions from west through north to east, in part of ridges of granitic and hornblendic gneiss and of granite. The ridges north of Wobleh Range are scarps of Jurassic limestone overlying gneiss, succeeding one another to the north like waves of the sea, facing north-east and dipping fairly steeply to the south-west. Between Hargeisa and Bulhar and Berbera are ridges of gneiss, succeeded eastwards by blocks of Eocene limestone covered by a horizontal sheet of black basaltic lava. Daimoleh Ridge, between the Golis Range and Berbera, is a large mass of intrusive granite. Bihendula Range, between Sheikh and Berbera, consists in part of granitic and hornblendic gneisses, but in part (largely on the south side) of Jurassic limestone scarps. Al Wein Range, near the coast, Ferrio Range, and the table-land south of Ankor consist of Eocene limestone surmounted in the case of the two first by a thick deposit of gypsum. The ridges between Ankor and the base of the Siradli scarp consist of scarps of Eocene limestone. Between the various ridges are flat sandy or pebbly plains, which, with the exception of the Huguf and Las Dureh plains, are always barren. Strictly, not only is there no true Inland Plain—as the ridges and hills occur sporadically all over the area between the main watershed and the Coastal Plain—but, excluding the ridges, the rise in elevation from the coast to the foot of the main escarpment is uniform, and the only difference between the Coastal Plain and the so-called Inland Plain is the occurrence in the latter and between it and the Coastal Plain of these ridges. The average distance between the coast and the foot of the main scarp is about 40 miles and the general increase in elevation over this distance is 2,500 feet.

The flats between the Maritime Mountains are composed partly of sand from the Dubar Sandstone, partly of limestone pebbles from the various scarps, partly—as in the country between Las Dureh and Sugali Ridge—of gypsum, but largely of granitic gneiss more or less obscured by an alluvium of quartz-felspar sand brought down by the tugs from the main watershed.

The Coastal Plain and the Maritime Mountains and the Inland Plain together constitute the division of Somaliland known to the natives as the "Guban" or "hot district."

(c) The main watershed extends in a general west-to-east direction from Somadu in the south-west corner of the Protectorate to the Italian frontier south-east of Las Gori.

It is best described in the following sections:—

(i) From Somadu to Hargeisa; (ii) from Hargeisa to Sheikh; (iii) from Sheikh to the Sugali Ridge; (iv) from Sugali Ridge to a point south of Hais; (v) from this point to the Italian frontier.

The watershed, and the country for a few miles to the south of it, is called by the Somalis "Ogo."

(i) It may be held to begin with the Marmar Range south-east of Somadu, a rugged dissected mountain range over 5,000 feet in height, composed in part of granitic gneiss, in part of greenish slaty rocks which appear to be extremely sheared lavas and agglomerates, and which certainly contain masses of conglomerate with a porphyritic matrix that may be in reality a volcanic conglomerate. From this range the watershed is continued in a south-easterly direction by the great Libaheli Range, an escarpment of Jurassic limestone 6,000 feet high, resting on extremely schistose mica schists and granitic gneisses, facing north-east, with foothills composed of faulted-down blocks of the same limestone. The Libaheli Range passes into the lofty Sigip and Wobleh Ranges which trend east and west, and which consist of granitic and hornblendic gneisses with numerous intrusions of granitic pegmatite. From the east end of Wobleh Range, as far as Hargeisa, is a broken series of ridges of acid and basic gneisses, in some cases, as round Boramo, capped with Jurassic limestone.

(ii) Hargeisa is situated on an undulating plateau, the height of which is from 4,500 to 5,000 feet. Behind it are scarps of Eocene limestone, and these scarps extend eastwards almost as far as Argan at the west end of Assa Range. The watershed is continued by Assa Range which, composed largely of granitic gneiss, runs in an easterly direction to Mandera at the bottom of the Jerato Pass, and the range passes directly into the Mirsa Plateau. A little to the south-east of Mandera begins the great escarpment of Eocene limestone known as the Golis Range, which, facing north, continues eastward to a point a little behind Sheikh. This escarpment has a general elevation along its entire length of nearly 6,000 feet. At the bottom of the cliff face and extending as far as Sheikh is a narrow flat plateau about a mile wide, formed largely of granitic gneiss and mica pegmatites and known as the Mirsa Plateau; its elevation is about 4,500 feet.

(iii) East of Sheikh, the Golis Range is continued by the scarps of Galgudan, the Dehemid bluffs and the Negegr Plateau, all high ridges of Eocene limestone with cliffs facing north, and with a gentle slope to the south, but, a mile or two north of the two former scarps and also forming part of the watershed, occurs the high ridge of Wagger, a mass of hornblende and granite gneiss which has an elevation of over 6,500 feet, and from the bottom of which to the north, numerous foothills jut into the Inland Plain. The rain which falls in the vicinity of Sheikh falls chiefly on Wagger Range and the Golis scarp to the west.

East of the Negegr Plateau, the watershed is continued by the serrated Ashararet Range composed also of hornblende and granite gneiss and extending in an east-west direction. At the eastern end, however, the range curves round through a semi-circle, and after running in a southerly direction for some miles, ends abruptly in Habrji Peak in the southern plain country. Ashararet Range gives place to the Eocene escarpment of the Sugali Hills which faces north-east.

(iv) Just north of the Sugali Hills, the watershed is formed of an elevated plateau of Eocene limestone, the scarps of which run in a northerly direction to a point some sixteen miles south of Hais. These scarps, which include those of Gaab, Siradli, Dud and Surad Ad, face west-south-west or west and range in elevation from 5,000 to 6,000 feet.

(v) South of Hais the main escarpment turns sharply to the east again, and continues in an east-west direction as the Afaf, Aroru and Al Hills as far as the eastern border of the Protectorate. The watershed attains its highest elevation in this section, the average height of the scarp being 6,600 feet above sea-level, while south of Mait, the limestone plateau on top of the scarp attains a height of 7,900 feet. This plateau is covered with cedar forest.

South of Zeyla in the west, the distance of the watershed or high level ridges, *i.e.*, Libaheli Range, from the coast is about 70 miles. Eastwards from this range the

distance becomes gradually less until, south of Berbera, the Golis scarp is about 40 miles from the coast. East of the Golis Range, the watershed represented by Ashararet Range and the Sugali Hills is again from 60 to 70 miles from the sea, but from Hais to Las Gori near the eastern border the main escarpment is never more than 16 miles in a direct line from it.

(*d*) On the south side of the main watershed the whole country slopes away with a small dip for many miles, at least as far as the Abyssinian boundary. The configuration of this part of the Protectorate is best seen from the top of the plateau south of Hargeisa, from the top of the Golis scarp, and from the high plateau north of Jid Ali in the east. Everywhere are rolling plains broken only here and there by isolated ridges chiefly of Eocene limestone, which, in contrast to those of the Inland Plain, dip at a very low angle to the south or south-east. There are no fault blocks, and with the exception of Habrji Peak, there are no igneous hills or ridges of igneous rock for many miles. Particularly is this true of the tract south and south-east of Hargeisa, in which, according to the maps at hand, there is not a hill of any size in an area of 120 miles from west to east and 60 miles from north to south. In the south-east corner of the Protectorate, it is true, there appear to be many ranges and hills, but though they have not been examined, there is reason to believe that they mostly resemble Bur Dab Range near Kirrit, *i.e.*, they consist of nearly horizontal Eocene limestone.

There are no rivers, and few well-defined tugs except near the summit of the watershed. The whole country is covered with a reddish sand or a calcareous or brownish soil, and this supports on the one hand a plentiful growth of khansa; on the other, a good growth of grass on which native ponies and sheep thrive exceedingly.

In general, looked at from some distance out to sea, the country appears to be formed of mountains and isolated ridges extending almost to the coast, and a lofty, continuous mountain range at some distance from the coast. The former are the constituents of the Maritime Mountains and Inland Plain; the latter is, in reality, partly a north-facing escarpment of the interior plateau and partly—west of the Golis Range—a continuation of this escarpment, formed of granitic and hornblendic gneisses.

The main direction of the drainage from the watershed is on the one hand northerly to the sea, on the other, southerly towards Abyssinia. On the north side of the main watershed, there are numerous tugs, some of which have cut through the face of the escarpment, and many of which have seamed the foothills at its base with ravines. Though they are now dry, there is evidence that at a former period, streams of considerable size must have flowed to the sea. On many of the fault blocks or ridges, at present streams which flow on the rare occasions when rain falls are gradually cutting a course in a southerly direction along the dip slope. As, in some cases, a tug now flowing north has to be deflected to the west or east to circumvent the ridge, it is clear that in the course of time a passage will be cut through the ridge by the combined efforts of both streams, and the larger tug will completely capture the smaller. There are numerous instances of this having already taken place, especially in the Bihendula Range and in the Jurassic ranges in the west, large tugs now existing in the gap between two ridges that at one time obviously formed part of one and the same ridge, and from the width of the gaps and the amount and depth of alluvium that is strewn all over the Coastal and Inland Plain, there is little doubt that large streams once flowed on the surface to the sea

On the southern slopes of the escarpment, especially north of Erigavo and Jid Ali in the east, the limestone has been extremely dissected by precipitous ravines, and excellent examples are to be seen of rounded spurs with constricted necks, which by a process of stream capture will ultimately form small round hills. In one instance, north-west of Jid Ali, the numerous south-flowing tugs have been cut off by a larger tug which runs in a north-westerly direction over the plateau, and, having cut a passage through the scarp, ultimately runs to the coast.

The rarity of tugs extending for any distance to the south on the southern slopes of the watershed is explained by the fact that the water which falls on the watershed is rapidly absorbed by the sands and sandy soil of the plains, and flows along underground channels for many miles southwards.

The country at some distance south of the watershed, and extending right into Abyssinia, in which there is little surface water, is called by the Somalis "Haud."

(B)—GEOLOGY.

The different rock groups of which the Protectorate is composed may be conveniently described in the following order, beginning with the oldest:—

11. Pleistocene and Recent Deposits.
10. Lavas.

9. Coastal Limestone Series.
8. Post-Daban Conglomerates.
7. Daban Series. Pliocene?
6. Gypsum Series. U. Eocene?
5. Eocene Limestone Series.
4. Dubar Sandstone. Cretaceous
3. Jurassic Limestone Series.
2. Inda Ad Slate Series. Paleozoic? or pre-Paleozoic
1. Crystalline Series (gneisses, schists, etc.).

1. THE CRYSTALLINE SERIES.—

The oldest rocks of the Protectorate and those on which the sedimentary series have been directly laid down are granitic and hornblendic gneisses with associated mica schists, quartz schists, foliated porphyries, granites, gabbros and pegmatites. The gneisses, in places singly but usually together, form, with the various limestones, the chief mountain ranges and ridges of the country, and, particularly in the west, they form a considerable part of the scarps even of the limestone ridges. They make up the ranges of Sigip and Wobleh; of Bur Madu north of Bur Ad; of the vicinity of Boramo and the country west of it; of the large area between Boramo, Hug and Gibele; of a large tract north of Hargeisa. They constitute the ranges of Assa north of Adadleh, the ranges round Mandera, the Mirsa plateau, Wagger Range and its foothills, Ashararet Range, Bihendula Range; part of Jirba Range, part of the country south of Hais, including the ridges of Ertoleh, Daga Har, Beyda Goyah, etc., and the range of Illagamait just west of Mait. Moreover, much of the surface of many of the plains of the Guban is composed of granitic gneiss, for example, Hussein plain, the plain near Hallimaleh, the plain south-west of Berbera, and the Galoka plain. Of the country between a line from Somadu through Boramo, Hargeisa and Sheikh to the Sugali Hills and the coast, fully half is composed of gneisses and foliated acid rocks. The granitic gneisses are pale or dark grey, in places yellow with a pinkish tinge; some are fairly, or, at least distinctly, foliated and of medium grain, others are indistinctly foliated and coarse-grained. In places, as at the west end of Libaheli Range, and just west of Fullenfuhl, near Boramo, they have been so altered by pressure as to form flaky mica schists. In the grey varieties, the mica is chiefly biotite and the mica schists comprise both muscovite and biotite schists. In all these varieties, the chief felspar is microcline.

The hornblendic gneiss is usually fine-grained, granular and rather indistinctly foliated. It forms large masses west of and around Boramo, and along the course of and especially at the head of Darinwadu tug south of Buk Gigo in the Gadabursi district; it forms the range of Bur Madu just north of the Jurassic limestone ridges of Bur Ad; it constitutes many of the hills and ridges east of Besare, a large part of Wagger Range and the Sheikh Pass, of Ashararet and Bihendula Range, and of Ertoleh Ridge south of Hais. A rather curious feature of the gneiss is that, in many places, it contains masses of a coarser, apparently unfoliated and much jointed epidiorite, which stand out usually as hills or small ridges. These are common round Boramo and in the upper part of Darinwadu tug. It is not certain whether they are merely masses which have withstood the pressure that caused the foliation in the hornblendic gneiss or whether they represent dykes intruded into the gneiss. From what has been seen of the relations of these rocks, they would appear to be merely harder and more resistant portions of the gneisses, but further work on their relations is necessary. With regard to the relative ages of the two gneisses, nothing definite could be established in the time that could be devoted to an examination of the outcrops showing the junction. No evidence was found which showed which was intrusive into the other.

Observations were made throughout the tour of the Protectorate with a view to establishing the direction of regional foliation of the gneisses. Much difficulty was experienced owing to the amount of faulting in the complex and to the fact that, although accurate data of this kind are generally to be obtained only by detailed work over considerable areas, observations could, under the circumstances, only be carried out over a small outcrop in any one place. There appear, however, to be three main directions. In the west, along the axis extending from the west end of Libaheli Range through Bur Ad Range to Mandera and the Mirsa Plateau, i.e., along what may be called the central axis of the country, the strike of the foliation is about east and west (in places about 5° north of east, in places about 5° south). Around Boramo and for some miles to the north, the strike of the planes ranges from N.5°E. to N.55°E. In the east of the Protectorate, from the northern slopes of Wagger, through Ashararet Range, in Bihendula Range, and in the gneissic area south of Hais (including Ertoleh, etc.), the prevailing direction is north-east and south-west.

Intruded into the granitic and hornblendic gneisses are a number of different rocks obviously of very different ages. In the neighbourhood of Boramo and in many

other places, foliated granites, clearly intrusive, stand up as hills. Occurring as dykes in these, but also elsewhere as dykes in the gneisses, are flesh-red and white aplites, some of which are garnetiferous. These are especially common in the west, north of Adadleh, and in the eastern part of Mirsa Plateau. In some places there are massive, quite unfoliated dykes of grey and pink granite. Daimoleh Mountain, for instance, south of Berbera, is a large mass of intrusive granite. Inifaru Mountain, and Gunra Hill, south-east of Las Gori, though outwardly of a bright red colour, are also intrusive granite masses. In the country round Besare, in Western Somaliland, are large masses of extremely foliated quartz porphyries. Just east of Sheikh and between it and Wagger Range is a large intrusive mass of black norite showing fluxion banding in places. In Gardeleh tug, in the west, is a large intrusive dyke of gabbro, and to judge from the boulders in many of the western tugs there must be other intrusions of the same gabbro. Between Hemal and Buk Gigo in the west, south of Lojebir Mountain, and in other places, are intrusive masses—mostly forming the flat surface of the ground—of reddish and dark-purple quartz porphyry.

Pegmatite veins are numerous in both gneisses. In Sigip and Wobleh Ranges, Libaheli Range and in the ridges from Mandera to Sheikh, they are not only especially numerous, but in many cases of great size. In Bur Madu Range, north of Daba Dulla, they occur in the hornblende gneiss in great abundance and exhibit extraordinary contortions.

In addition to the granitic and hornblendic gneisses, there occur in the Ulauleh tug, in the Gadabursi District, some quartz and graphite gneisses. Their field relations were almost wholly obscured by débris, but, as they are friable and granular, seemingly devoid of felspar, and as no similar rocks have been found forming part of the normal granitic gneisses, they would all appear to be of sedimentary origin, and younger at any rate than the granitic gneisses.

With regard to the age of the Crystalline Series, little of a definite nature can be stated. The granitic and hornblendic gneisses may be regarded as of Archæan age, and the quartz and graphite schists, if, as is probably the case, they are of sedimentary origin, may be provisionally classed as of pre-Cambrian age. The norite, the gabbro and the flesh-red aplite dykes are certainly the youngest of the intrusions described. Obviously, however, between the formation of the gneisses and the intrusion of these dykes, a vast interval of time must have elapsed to allow of the intrusion and subsequent foliation of the foliated porphyries of the Besare neighbourhood and of the foliated granite of Boramo and elsewhere, and as these dykes have nowhere been seen intruding one another or any of the sedimentary formations, it is impossible to form any idea of their age.

2. Inda Ad Slates.—

This series, which has been recognised for the first time in Somaliland, outcrops about twenty-four miles south-east of Las Gori over an area of flat, gently undulating or low hilly country, at least twenty miles long from west to east, and five miles wide from the base of the main escarpment northwards towards the coast. It is typically developed in the neighbourhood of the "durdur" and pools of Inda Ad. The rocks consist of slates, greyish and greenish quartzites, slaty sandstones and beds of limestone. All the beds dip either vertically or at a high angle to the west (at Inda Ad), so that the whole outcrop is formed of the edges of the beds. Their prevailing strike is N. 20°—30° W. The dip at Inda Ad ranges from 70° to vertical, but is chiefly from 80° to vertical in a direction a little south of west. At Kul, however, some twelve miles further east, the dip is about 40° in a direction N. 80° E., *i.e.*, a little north of east. This change in the dip argues either a fault or a fold, but if folding has taken place, it must have been extremely acute.* The comparatively low angle of dip, 40°, is unusual in the series, and it appears to be only local. No attempt could be made to investigate the possible presence of such a fold or the cause of the change. The series strikes directly under the Eocene and Dubar Sandstone of the main escarpment to the west, and doubtless continues for some distance underneath it, and, as the latter is practically horizontal (it dips to the south at about 5°), a most striking uncomformity is visible from the top of the scarp looking eastwards.

The slates comprise white, grey, purple, black, striped greenish and reddish varieties, are very fissile, and in places—as in Hedwein tug—could be used for building purposes. Between Inda Ad and Kul, they are intruded by a great number of white and reddish ferruginous quartz veins or reefs, which occur in two series, one parallel to the bedding and the other at right angles to it. The reefs range in thickness from one inch to several feet. In places they contain impressions of pyrite crystals.

Interbedded in the slates are several bands of limestone, and these bands form well-marked features in the landscape, standing up as ridges above the level of the slates

* In view of the great apparent thickness of the slates and the high angle of dip, careful mapping may ultimately show the series to have an "isoclinal" structure.

to a height, in places, of 100 feet. The bands are from two to thirty feet thick, and, owing to the reddish staining on the sides and the greyish surface, they closely resemble the scarps of Eocene limestone. The dip is parallel with that of the slates. In colour, on the fresh fracture, they are pale yellow, nearly black, variegated red and white, brown and brownish-red and ferruginous and then partly striped with hæmatite veinlets.

Though slaty sandstones occur in the series at Inda Ad, the grey quartzites were found for the first time in Huliah tug some few miles south-west of Kul, where, with a thinly laminated structure, they exhibit the same strike and dip as the slates at Inda Ad.

Grey quartzites also occur some three miles south-west of Jiridli, and in this locality they are intruded by large dykes of saussuritic epidiorite. At Jiridli well, there is another large outcrop of grey quartzites which enclose fragments of the epidiorite with marked alteration borders due to assimilation. The presence of these fragments is remarkable, because they are not directly connected with an epidiorite intrusion.

At Las Bar, four miles north-east of Kul, the slates appear to be intruded by masses of granite, of which the hill Inifaru is the most prominent; thin veins of the granite run parallel to the bedding planes of the slates.

The age of the Inda Ad Slate Series is unknown. A careful search was made of several large outcrops, but no fossils or traces of fossils whatever were found in any member of the series, slate, sandstone or limestone. They must, however, be considerably older than any of the other sedimentary formations, as they have been subjected to movements which have been great enough to tilt the whole series almost through a right angle, movements which were complete before any of the other sediments were laid down. Probably they are of Palæozoic or pre-Palæozoic age, and they may correspond to the slates of the Karagwe Series of the Transvaal.*.

Similar slates occur some sixteen miles south-east of Hashau, up Goru tug in the vicinity of Marodi Ur, near the bottom of the scarp of the Afaf Hills. About one mile up Goru tug from where the track from Kelma meets the tug, is an outcrop of greenish, yellowish and grey slates which dip vertically and of which the edges of the bedding-planes strike north and south. Further up the tug, at Addi, the slates are reddish, noticeably cleaved and jointed; the bedding planes dip west at an angle of 30° and the strike of the cleavage is N. 20° E. Above Addi, are black unfossiliferous limestone bands interbedded with the slates. The series appears to pass underneath the Afaf scarp. There is little doubt that it is of the same age as the Inda Ad Slates.

Again, at the north end of Jirba Range (south of Karam), on the south side of the Bihen Gaha Pass, is an outcrop of white, grey, purple and black slates which so closely resemble those at Inda Ad that they may be included in this group. The rocks—which are exposed on the sides of two or three of the hills—have been much disturbed. They appear to be intruded by more or less felsitic quartz-porphyries and dykes of white and pink aplitic granite, and the whole mass has been extremely sheared. The strike of the planes of shearing is N. 15°—30° E., and so far as could be determined, the dip of the slates is E.N.E. and ranges from 60° to vertical. Most probably the slates lie directly on the gneisses which make up the core of the range. A noteworthy feature of the outcrop is that, intrusive into the granites and into the slates and porphyries, are thin black dykes of epidiorite which run parallel with the planes of shearing, a fact which shows that at least some of the epidiorites of the Protectorate are of later age than the Archæan and pre-Cambrian.

Another large outcrop of slates occurs some miles south of the coal deposit at Hedhed, between Godadi and Hedhed, on the track from Las Dureh to Ankor. The slates form hills and ridges which trend in a north-north-easterly direction. They are clearly sedimentary, extremely cleaved, jointed at right angles to the cleavage, and the bedding-planes are more or less parallel to the cleavage. The strike of the cleavage is N. 25° E. and the slates dip N. 65° W. at an angle of 60°. The rocks are, in different places, grey, yellow, greenish, brownish and black in colour, very fissile, in part carbonaceous, in part silicified. The Eocene limestone of the surrounding country is faulted against them. A prominent ridge of the slates runs in a northerly direction on the east side of Hodmo tug to within a few miles of Ankor.

The hills of yellow-stained marble occurring about 16 miles south of Ok Pass, known as Demirjog, and described later in the section on Marble, may belong to this Inda Ad series. In Demirjog, the marble is apparently intruded by dykes of epidiorite foliated and massive, and it has been pointed out above that in Jirba Range, dykes of a similar rock intruded the slates outcropping in the range. A patch of a similar marble was found on the track at Dorjibis in Western Somaliland, but the field relations of this outcrop were even more obscure than those of the Demirjog marble.

* See Gregory: The Rift Valleys and Geology of East Africa, p. 41.

3. Jurassic Limestone Series.—

Rocks of Jurassic age attain a considerable development both in British Somaliland and in Abyssinia, and there is some reason for believing that these rocks are part of a land mass which once extended eastwards and formed part of the ancient continent of Gondwanaland.* In Somaliland, the chief occurrence of the series is in the Gadabursi country, in the west. There it forms the majority of the ridges and scarps, Libaheli Range, Bur Ad Range, Karimo Range, Kara Mut Ridge, Balaat Ridge, Aga Sur Range, Eilo Range, etc. The scarps of the ranges all trend in a N.W.—S.E. direction, and, north of the gneissic Wobleh Range, they follow one another like successive waves of the sea, all parallel and at intervals in some cases of a few hundred yards, in others of two or three miles, the intervening spaces being generally occupied by gneiss. They are all fault-blocks produced by large strike faults. In nearly every scarp, the limestone may be seen resting on gneiss, hornblendic or granitic, directly or with an intervening sandstone bed. The dip of the limestone is to the south-west, at an angle of from 25°-30°, and the dip is extremely regular in all the ranges. Smaller limestone scarps, but apparently with lower angles of dip, exist south-east and south of Boramo, and there is evidence that the limestone mass once covered a much larger area than it does at present, for the pebble-sandstone bed which marks the bottom of the series in the scarps occurs over a fairly wide area in the vicinity of Besare, which is now formed chiefly of gneisses, foliated porphyries and red granites.

Eastwards of the Gadabursi district, outcrops of the Jurassic series become less and less common. Only a few are to be found in the Central district, at Bihendula, at Ida Kabeita, at Bihen Gaha, at Ambal and the ridge of Tar between Ambal and Karam, in a ridge just behind Karam, and in the pass through the Dubriat Range from Bosti to Berbera, on the side of the track. East of a line from Ambal to Karam, no beds of this age have ever been recognised. Moreover, as far as known, no Jurassic outcrop exists in that part of the Protectorate south of the main watershed.

In Somaliland the outcrop which probably best shows the constitution of the series is at Bihendula, about 25 miles south of Berbera. Fossils from this locality were examined by Prof. J. W. Gregory in 1896, and, from the determinations, the age of the rocks was held to be Bathonian†. Collections, however, made by the present writer not only from Bihendula, but from several localities in Western Somaliland, have recently been examined at the British Museum of Natural History, and the result of the determinations, particularly of various Ammonites by Dr. Spath, shows clearly that a large part, if not the whole, of the series is of Kimmeridgian and not of Bathonian age. A full account of the significance of the fossil evidence will be given later in a separate paper on the geology of the Protectorate. As stated by Drs. Wyllie and Smellie, who made a careful study of the Bihendula outcrop, and confirmed by the writer except as regards the thickness of the strata which was not measured, the total thickness of strata exposed is 3,840 feet, made up of the following members, beginning with the oldest:—

Top.

7. 600 feet. Thin bedded, grey compact limestone with shaly partings. Ammonites common.

6. 1,700 feet. Greenish-grey and yellow calcareous mudstones and shales with thin beds of argillaceous limestone; the shales are often gypseous and contain Ammonites and Belemnites throughout.

5. 300 feet. Grey compact limestone in beds 1-3 feet thick.

4. 500 feet. Greenish-grey and yellowish calcareous mudstone and shale with thin beds of argillaceous limestone; shell banks in places.

3. 200 feet. Limestone, thin bedded, somewhat shaly at the base, with echinoids, brachiopods and lamellibranchs; more massive coral limestone on top.

2. 500 feet. Yellow and grey, gritty, current-bedded sandstone.

1. 40 feet. Basic lava, consisting of at least two separate flows.

Bottom.

A characteristic feature of nearly all the limestone is the presence either of dark grey, nearly black bands, or of almost black patches in it. These dark-coloured portions give a fœtid odour on the fresh fracture. In places in the series, as at Bihen Gaha, are bands of black argillaceous and calcareous rock, which probably contain kerogenous material.

* Gregory: *Geol. Mag.* Vol. III., 1896, pp. 289-296.
† Gregory: *loc. cit.*

In the west, the succession of the beds is not quite the same as in Bihendula Range. The maximum thickness, as measured by Wyllie and Smellie, is about 3,000 feet. No lavas occur at the base. On the other hand, in Bur Ad Range and in a hill south-east of Hemal, the shales, which are, with the exception of the sandstone, the lowest beds exposed, are intruded and dislocated by a basaltic dolerite dyke. The basal sandstones are only from 10 to 50 feet thick and at the bottom have a pebble bed of red, white and yellow quartz pebbles about the size of a walnut. The remainder of the series consists of a lower and an upper limestone, composed of bands of compact limestone from 1-3 feet thick, with an intervening zone of shale and mostly yellowish mudstone. In the extreme west, north of Somadu and at least as far as Hensa, there is a great thickness of sandstones which have been hitherto mapped as basaltic lava. Whether these sandstones are a continuation of the basal Jurassic sandstone is not yet known, but it is noteworthy that a little to the south-east of Somadu are two hills of limestone, presumably overlying the sandstone, and, though no fossils were found in this limestone, owing to its proximity to the main Jurassic outcrop at Debraweina, it is at least possible that it is of this age.

The compact limestone bands of the Eilo Range form a good lithographic stone. The shale zone, especially near Meragelleh, contains thin nodular beds, the nodules, of which some are a foot in diameter, containing Ammonites and fossil wood.

At Meragelleh, and both on the side of the Durdur Ad tug at Gardeleh and in the bed of the tug itself, the shale zone contains beds of undoubted kerogenous shale (*see* below). The shale in a hill on the side of the tug, a little south of the junction of the Durdur Ad with the Gardeleh tug, consists of thin, brownish-black laminæ, with selenite films along the joint planes and between the laminæ. In the Durdur Ad tug bed, the shale forms a compact brownish-black very fissile mass, with numerous shell impressions on the surface of the laminæ. Tests of the shale (the results of which are given below) show it to be undoubtedly kerogenous.

South-east of Bihendula, at Ida Kabeita, is a small outlier of Jurassic limestone faulted against rocks of the Crystalline Series, containing a yellowish calcareous mudstone with shells of Rhynchonella.

At Bihen Gaha, north of Jirba Range, the series is represented by an upper fœtid and flaggy and a lower more compact limestone with a brownish-black shale zone between. The shale zone contains bands of dead-black argillaceous and calcareous rock, and numerous belemnites, fossil wood, etc.

At Ambal, the Jurassic beds are exposed in a ridge which trends north and south. The ridge is flanked on the east side by Dubar Sandstone. The series consists of black kerogenous shales 200-300 feet thick, overlain by sandy yellow shales 50 feet thick, and these are in turn overlain by bands of fœtid limestone interbedded with more or less marly grey shales. The lower beds of the Bihendula outcrop are absent. The strata of which the hill is composed dip steeply to the north-east, less steeply to the north and south, and as the west side is covered by blown sand, the hill presents the appearance of a dome. As the ridge of Tar to the north, however, and the other outcrops of Jurassic rock as far north as Karam are faulted on the west side, it is fairly certain that Ambal Hill is similarly faulted, and that it is not a true dome. The shale zone contains numerous large calcareous nodules which, as at Meragelleh, contain Ammonites and fossil wood.

The ridge of Tar, north of Ambal, shows the same sequence of beds and the same structure except that it is clearly faulted on the west side, which is not masked by blown sand.

As Jurassic rocks are known to occur in great thickness in the Harrar Plateau in Abyssinia, it is evident that the main Jurassic sea existed in Abyssinia and Western Somaliland, and that only an arm extended eastwards into the middle of the Protectorate, an arm which, to judge from the presence of gypsum in some of the Bihendula shales, consisted in part of isolated pools, and which did not extend beyond a line from Karam southwards to Ambal.

4. Dubar Sandstone.—

Overlying the Jurassic limestone, particularly in the central part of the "Guban" country, and in a notable outcrop on the south-western slopes of the Eilo Range and west of Kabri Bahr in the Gadabursi district, is a succession of fairly fine-grained, predominantly red, brown and yellow sandstones commonly without associated clays, slates or any argillaceous material. These sandstones form a noticeable part of most of the limestone ridges of the Maritime Mountains and Inland Plain, and derive their name from the Dubar ridges on which is their nearest outcrop to Berbera. For purposes of description, they may be considered under two heads:—(*a*) the sandstones of the "Guban" country, (*b*) those of the main scarp or main watershed:—

(*a*) These, in addition to the outcrops in the west just mentioned, occur in the scarps of Al Wein Range, of Ferrio Range and of isolated hills south-east of

Berbera, on the flat south of Bihendula Range, and in great extent and thickness in the extremely dissected country south of Karam and also south of Ankor, and between it and Las Dureh. They appear to be quite unfossiliferous, but as they lie conformably on the Jurassic in Eilo Range and elsewhere, and as they, also, in many places in the "Guban," clearly underlie the Eocene limestone, they may reasonably be regarded as of Cretaceous age. Their relation to the Eocene limestone appears to be comformable in some places and uncomformable in others. The strike and dip of the beds are not markedly different from those of the overlying strata in any one outcrop, though they differ considerably in different fault blocks. The sandstones exhibit current-bedding and contain in many places numerous large and small mammillary and botryoidal concretions, some quartzitic, others calcareous. Exceptionally, as in the vicinity of Biyo Dader, they contain thin bands of red mudstone, and on the track between Biyo Gulan and Biyo Dader, some thin bands of yellow shale appear. In the Ambal tug, and in parts of Jirba Range, the sandstones are of a deep-green colour. According to Wyllie and Smellie, the beds attain a thickness of at least 5,000 feet in the vicinity of Biyo Dader, though elsewhere in the coastal districts, the thickness appears to be from 2,000-3,000 feet.

(*b*) The main limestone scarp from the Golis Range eastwards almost to the Italian frontier, consists of a thick cap of Eocene limestone underlain generally by a great thickness of sandstones. The latter are best seen in the scarp at Darass, some twenty miles west of Sheikh. They comprise alternating beds of soft white, grey, yellow, brown, red, purple, and almost black sandstone, all exhibiting marked false bedding, and, so far as could be ascertained, having a slight dip (about 5°-10°) to the south-south-east. Near Gan Libah, at the top of the series, is a purplish red jasperoid slaty stratum, a few inches thick, containing numerous pyritic nodules altered to limonite. The Jurassic Series which underlies the "Guban" sandstones is absent in the main scarp, and the beds rest directly on the granitic gneiss. These are the sandstones which previous writers on the geology of Somaliland have referred to as "red unfossiliferous sandstones of unknown age." They are undoubtedly unfossiliferous, but there is little doubt that, underlying the Eocene limestone as they do, they are the counterpart of the Guban sandstone and of Cretaceous age. In the Golis Range they are about 900 feet thick. Westward from this range the beds occur at Hargeisa and on the track between Hargeisa and Gibele, where they resemble the Eilo Range sandstones. Near Abudleh, some miles west of Hargeisa, they are in places indurated to quartzite. From the nature of the sandstones—the prevalence in them of current-bedding, the great variety of colour, and the total absence of traces of fossils—they would appear to have been laid down under terrestrial conditions.

5. Eocene Limestone Series.—

With the exception of the few ridges already stated to be of Jurassic age, and a few small limestone hills belonging to the Coastal Limestone Series, to be described later, all the limestone ranges of the Guban from north of Hargeisa eastwards, and the main scarp extending from Gan Libah in the Golis Range eastwards to the Italian frontier, consist of a limestone which, as the result of the examination of various fossils by Dr. R. B. Newton in 1905, is definitely of Eocene age. Neither the ranges nor the main scarp, of course, consist wholly of limestone, the latter being generally underlain by Dubar sandstone and overlain in places—particularly in Al Wein and Ferrio Range—by gypsum beds of greater or less thickness, but in all cases the most noticeable feature of the face of the scarps themselves is this limestone. Especially is this the case in the eastern districts, from Galgal to south-east of Las Gori, where the lofty scarps of Siradli, Dud, Surad Ad, the Afaf, Aroru and Al Hills, consist of a great thickness of massive limestone conspicuous for its reddish colour, due to surface stain.

The maximum thickness of the Eocene limestone observed by Wyllie and Smellie in the area examined by them was about 800 feet, but in the eastern districts, from Galgal to behind Las Gori, the thickness is much greater, probably 2,000 feet or more.

The series consists of (*a*) a lower massive limestone, (*b*) an upper whitish, chalky, more porous, more thinly bedded limestone associated with which are very thin, yellowish clay shales, in places gypseous. There may be a sandstone stratum under the massive limestone, for, underneath the coal seam at Hedhed in the plateau south of Ankor, which is at the bottom of the Eocene limestone, is a bed of soft, whitish sandstones. At present, it is doubtful whether these are the bottom of the Eocene Series or the top of the Dubar Sandstone.

The massive limestone is mostly hard, yellowish in colour, with a surface grey, white or bright red, owing to iron staining. It is fairly fossiliferous, containing corals, gasteropods, lamellibranchs and echinoids, but most of the fossils are more or

less silicified, and stained reddish. In the rock also are numerous small patches of iron-stained flint, some of which also contain fossils or fossil impressions.

The upper limestone is best seen in the eastern districts, on the top of the Afaf, Aroru and Al Hills. It is more porous, lighter in colour and more chalky than the massive, and contains more fossils—echinoids and various shells, amongst which, in the Laliskwe Plateau, west of Hargeisa, are some very large gasteropods. Smaller gasteropods shells are also very common on the plateau north of El Afweina. A fairly typical section of this upper limestone division is exposed at Garab Garreh Hill, south of the main scarp of the Afaf Hills. The outcrop consists of yellow gypseous clay-shales about 30 feet thick with intercalated slaty and chalky limestone bands at the bottom of the hill, succeeded by a stratum of eroded grey chalky limestone, the latter containing similar fossils to those in the chalky bands of the shales. The total thickness of beds exposed in the hill is about 300 feet, and the strata dip only very slightly to the south.

There appears to be a gradual passage of this limestone series with its yellow shales into the Gypsum Series which overlies the Eocene beds, which indicates a gradual drying up of the Eocene sea, and a gradual formation of salt water lagoons or inland seas. The thickness of the upper limestone is about the same as that of the lower in the "Guban" country, about 400-500 feet, but in the east, the massive limestone is very much thicker. In the west, the Eocene Series first makes its appearance some miles west of Hargeisa, where the upper limestone forms the Laliskwe Plateau. It gradually becomes thicker eastwards and reaches a maximum thickness in the plateau south of Hais. Just as, therefore, the Jurassic limestone attains its greatest extent in the west and disappears gradually eastwards until none at all is found east of Ambal, so the Eocene limestone reaches its greatest extent in thickness in the east and gradually thins out and diminishes in extent westwards until none occurs west of Gibele, between Hargeisa and Boramo. The main Jurassic sea was in the western half of the Protectorate, the main Eocene sea in the eastern half.

The actual horizons to which the massive and upper limestones of the Series belong cannot be stated until the completion of the examination of the numerous fossils collected during the tour.

6. The Gypsum Series.—

On the southern slopes of Al Wein Range, about 16 miles south-south-east of Berbera, and of Ferrio Range about 35 miles south-east of Berbera, the Eocene limestone is overlain by a great thickness* of greyish-white massive gypsum beds. The latter lie conformably on the limestone and dip to the south at an angle of about 20°-25°. The Gypsum Series is seamed with numerous ravines, all with very precipitous sides, and, as exposed in these, it consists almost wholly of greyish gypsum indistinctly veined, with patches, streaks and brecciated blocks of anhydrite more or less altered to gypsum. In places, are veins of selenite and satinspar and thin partings of hard shale. In Ferrio Range, at the bottom of the southern slopes, yellow shales make their appearance at the base of the series, and these shales, besides being gypseous, contain in places masses of crystals of celestite. Indeed, celestite crystals can be obtained in every outcrop of the Gypsum series throughout the Guban.

The series also occurs on top of the main scarp south of Hais, the hills between the edge of the escarpment and Erigavo being all capped with greyish gypsum beds, similar to those in Al Wein Range, but by no means so thick. Moreover, the whole of the flat country in the vicinity of Dodab and Las Adey, and round Dabbar Dalol south of El Afweina is floored by gypsum, the surface of the Dabbar Dalol neighbourhood consisting of large flat slabs of opaque white alabaster. Gypsum beds of considerable thickness also occur at Jid Ali and further east, and much of the country in the south-east corner of the Protectorate, *e.g.*, round Kirrit, at Ain Abo, etc., is formed of the series.

In the hills north of Erigavo, the beds exposed are somewhat different from those of Al Wein and Ferrio Range. At the base are thin beds of gypsum; these are succeeded in turn by a thin stratum of white clay or marl with fossil bivalves, and a stratum of slaty nummulitic limestone, and on top is a compact somewhat fissile or slaty limestone. In one small hill, on top of the gypsum bed, is nummulitic limestone with oval and discoid flints.

It is evident that at the close of the Eocene period the sea which deposited the limestone retreated, leaving large inland seas over most of the eastern half of the Protectorate, which were liable to inundation and which, on finally drying up, left behind great masses of gypsum and anhydrite with associated celestite. Whether, however, the gypsum of Al Wein and Ferrio Range is of the same age exactly as that of Kirrit, Ain Abo and the top of the main scarp at Jid Ali and elsewhere is not

* 2,000 feet according to Wyllie and Smellie.

known, though some light may be thrown on the question by the determination of the fossil collections made by the writer.

7. THE DABAN SERIES*.—

On the southern slopes of Al Wein Range, about 16 miles south-east of Berbera, near the bottom of the outcrop of the gypsum beds, a thick series of sandstones and clays overlies the latter. The series extends for several miles along the slopes of the range, and from it southwards over the flat country to Dagaha Shabell and the east end of Bihendula Range. It lies apparently conformably on the Gypsum Series, the dip of both series in the vicinity of Khal Der ranging from 10°-20° to the south. As the beds stretch for about 10 miles southwards, as there are no signs of any strike faulting and as the dip of the beds gradually diminishes to about 5°, their greatest thickness is probably over 10,000 feet. The series consists of a lower division, exposed on the Al Wein slopes, made up of thick red, brownish-red and yellow sandstones and red, chocolate-coloured and in places green clays; and an upper division characterised by green clays and fewer reddish sandstones. About a mile north of Khal Der Well, and near the contact of the series with the gypsum beds, a seam of lignite is exposed, about one foot in thickness, and another outcrop, probably of the same seam, occurs about a mile further east. The occurrence of this lignite is described later on. The beds exposed in succession from the Gypsum Series southwards are:

Yellow sandstones with green and chocolate-coloured shaly bands.
The lignite seam with associated chocolate-coloured shales.
Thick brown and yellow sandstones.
White gypseous sandstones and clays, and yellow shaly sandstones.
Brick-red sandy clays, very gypseous.
Thick brick-red argillaceous sandstones.

Then follow the members of the upper division:—

Green, yellow and brown clays.
White clayey sandstones.
White sandy slates thinly laminated.
Pale yellow gritty sandstone with a seam of black flint one foot thick.
Pale purplish sandstone with a thin conglomerate on top.

Throughout the whole series, except in the lowest and in the non-argillaceous sandstones, gypsum is common. A little east of Khal Der, large selenite slabs occur on top of the yellow sandstones. South of the Well, and about 2,000 feet above the base of the series, are yellow and brownish argillaceous sandstones containing numerous fossils—banks of oysters of several species and other mollusca, etc., and at a horizon about one mile west of the Well, large shells of a Nautilus, and silicified wood. These clayey sandstones are overlain again to the south by yellow and white gypseous clays which contain numerous shells, the calcium carbonate of which has been completely replaced by gypsum.

The red, brown and yellow sandstones very closely resemble the Dubar Sandstone, even to the extent of containing similar mammillary forms.

From the nature of the sediments and the character of the fossils—oysters, cephalopods, silicified wood—the series was obviously formed in a large lagoon or inland sea, between which and the main sea, connection was not entirely broken off, but into which enormous quantities of sediments were discharged. The age of the series will not be definitely known until the fossils collected from it have been determined, but it is probably Pliocene. The upper division passes, to the south, under beds of pink gritty sandstone and massive conglomerates, but at Dagaha Shabell, green and red sandstones and chocolate-coloured gypseous clays again make their appearance with a dip of 10-20° to the south-south-west, with the conglomerates faulted down against them. It is in these sandstones and clays that petroleum occurs, and considerable difference of opinion has arisen between Beeby-Thompson and Ball on the one hand, and Wyllie and Smellie on the other, as to whether they belong to the Dubar Sandstone Series or to the Deban Series. The subject is discussed and further description is given of the Dagaha Shabell outcrop later on, in the section dealing with Petroleum.

8. POST-DABAN CONGLOMERATES.—

In the vicinity of the Daban coffee-shop, the Daban Series passes under a mass of conglomerates and very soft pink and yellow sandstones, which are well exposed in the Daban tug south of the coffee-shop. The conglomerates are composed chiefly of Eocene limestone pebbles, but pebbles of granitic and hornblendic gneiss are also present, especially in the neighbourhood of El Jifli well. The pink sandstones forming the banks of the tug form rather a striking feature of the landscape as far south almost as the mouth of the Dagaha Shabell gorge. The thickness of the conglomerates and

* The name "Daban Series" was given to these rocks by Drs. Wyllie and Smellie, who first recognised them.

sandstones amounts to about 500 feet, and in places the sandstones contain bands of conglomerate and *vice versâ*. Just north of the Dagaha Shabell rock, they have been thrown down by a fault to the level of the Shabell beds. As far as could be seen in the Daban tug, they are conformable on the Daban Series, the dip of both formations where first seen in the tug being about 5° to the south. The conglomerates, however, gradually become horizontal and then, south of Dagaha Shabell, they dip slightly to the north. They are unconformable on the Daban Series of Dagaha Shabell at the east end of the Bihendula Jurassic limestone, and at Dagaha Shabell and elsewhere they appear to contain large solid masses of Eocene limestone. The origin of these limestone masses and their relation to the conglomerates is discussed later in the section on Petroleum.

9. Coastal Limestone Series.—

The beds of this series occur at various places near the coast between Bulhar and Ankor, and there are small masses of limestone between Gedweda and Las Gori, and east of Las Gori as far as Elaiya, which may also belong to the series. The rocks are typically exhibited at Dubar about eight miles south of Berbera, and about 600 feet above sea-level, and at Dubino Hills some 15 miles south-west of Berbera and about 1,000 feet above sea-level. They consist of coarse conglomerates, sands and whitish and yellowish gypseous clays overlain by yellowish coral limestone, in which are numerous fossil corals of different kinds. Some fossil shells occur in the clays under the limestone a little south-west of Dubino Hills. The age of the beds cannot be determined accurately until the corals and shells collected have been examined, but they are certainly post-Eocene and post-Daban, as, at Dubar, they abut on a dissected Eocene-Dubar Sandstone scarp, and their contained fossils—especially the corals—are clearly of later age than the fossils of the Daban Series. The beds have been considerably faulted.

10. Lavas.—

Lavas of several different ages occur in Somaliland. In the extreme west, on the track between Somadu and the Marmar Range, and about 3¼ miles south-east of Somadu, two large parallel escarpments striking north-west-south-east and dipping south-west at an angle of 30° were encountered. These escarpments consist of at least two flows of greyish-white spherulitic rhyolite, and as both the ridges are of the same constitution, strike and dip, they probably represent a formation that has been repeated by strike faulting. All the surrounding country consists of yellow sandstone capped by horizontal basalt, and, though nothing certain is known of the age of these rhyolites, they must be considerably older than the basalt. It is noteworthy that both the strike and dip of the series correspond very closely with the strike and dip of the Jurassic limestone scarps of the Gadabursi country.

Again, Marmar Range south-east of Somadu consists in part of extremely sheared greenish slaty rocks which, on microscopic examination, appear to be composed of a porphyritic matrix enclosing fragments of rocks of different composition, andesite, slate, etc. Moreover in a gorge in the range about half-way along the track through it, is an outcrop of what appears at first sight to be a conglomerate. Closer examination, however, shows that this conglomerate also has an igneous porphyritic matrix, and that like the green slate facies it has been extremely sheared. Though further examination of the range is necessary before a definite conclusion can be come to, it would appear that these greenish slaty rocks are facies of an extremely sheared volcanic agglomerate. If so, the agglomerate is in all probability of great age, certainly older than Jurassic, since Jurassic limestones rest unconformably on parts of the range.

Another rock of distinctly clastic or agglomeratic character occurs in Bihen Gaha Pass at the north end of Jirba Range and close to the outcrop of Jurassic limestone and kerogenous shales west of the outcrop of slates. The microscopic sections of the rock, however, are not yet to hand, and it cannot at present be said whether it is of volcanic origin or not.

At the base of the Jurassic Series in Bihendula Range and resting directly on the gneiss occurs an appreciable thickness of partly decomposed basalt. According to Drs. Wyllie and Smellie, the basalt consists of at least two flows. It is therefore obviously either early Jurassic or pre-Jurassic. At Daba Dulla, however, in the Bur Ad Range, and at Hemal, south-east of Zeyla, the basalt at the base of the Jurassic is not a flow but a dyke that has considerably dislocated and baked the overlying shales. Further, in the extreme west of the Protectorate, west of Abaswein, Hensa and Somadu, all the surface is covered with a thickness of from 20 feet upwards of horizontal black basalt.

West of Berbera, and in the triangle Berbera-Bulhar-Hargeisa, large areas of country, *e.g.*, the Damel Plateau, are covered by a series of basalt flows which have a maximum thickness of several hundreds of feet. These lavas lie unconformably, not

only on the Eocene limestone, but even on the Coastal limestone. They are everywhere horizontal or nearly so, and the level of their surface is from 1,500-2,000 feet above sea level.

In the extreme east of the Protectorate, just south of Elaiya and about forty miles east of Las Gori, similar basalt lavas occur on the surface (apparently) of Eocene limestone.

The age of the basalts, excluding those near the French border, is at least later than Eocene and even later than that of the Coastal limestone, and it is clearly later than that of any of the main fault systems. The source of the lavas could not be determined, as, in spite of a search as opportunity offered, no necks or plugs were discovered.

Of the basaltic lava near Abaswein, Hensa and Somadu, all that can be said at present is that it is clearly younger than the great sandstone mass in the same district.

In Western Somaliland, especially in the country between Hensa and Somadu, there are numerous volcanic dykes of andesitic or variolitic character, which also intrude the sandstone mass.

There appear, therefore, to be in the Protectorate volcanic rocks of four distinct ages, viz.: (*a*) the sheared agglomerates of the Marmar Range and possibly the clastics of Jirba Range; (*b*) the spherulitic rhyolites between Somadu and the Marmar Range; (*c*) the basaltic lava at the base of the Jurassic Series; and (d) the recent basalt flows which form part of the surface of the country west-south-west of Elaiya, near the Italian frontier, and west-south-west of Berbera and south of Bulhar. At the present time, there is no evidence at hand to indicate whether or not the basaltic lava of the extreme west, at Abaswein, Hensa and north-west of Somadu, is of the same age as the lavas of (*d*).

11. Pleistocene and Recent Deposits.

These comprise the raised coral reefs along the coast; the alluvial gravels and sands of the tugs and those which occur on the plains between the tugs; and blown sand, which occurs in large quantities as yellow ridges north of Biyo Dader Well, and between it and the Dubar Sandstone plateau south of Karam, on the west of Ambal Ridge and on the coast in the vicinity of Karam, Ankor and Hais. Coral reefs and platforms exist east and west of Berbera, behind Ankor, east of Kelma and Mait, and near Elaiya. They are only a few feet above sea-level, but in places extend back into the Coastal Plain for some hundreds of yards. Near Wagderia Well, between Las Gori and Hais, large deposits of shells and corals occur in the banks of the tugs at some distance from the coast. These are now being examined.

It is worthy of mention that in the gravel banks of the Issutugan tug, which runs from near Hargeisa to Bulhar, stone implements have been obtained, which, there is reason for believing, belong to more than one period. Some, four inches long and about three inches wide and of a round-oval shape, appear to have been used as missiles; others, about half as large and with a more pronounced point, may have been used for cutting or scraping; and others, again, about two inches long at the base and tapering to a fine point, were almost certainly used as spear heads. It is asserted that a collection of these implements was made years ago by Dr. Seton-Kerr, but the present writer has so far been unable to get access to any publication he may have written concerning them.

(C)—FAULTING AND SEQUENCE OF GEOLOGICAL EVENTS.

It is generally believed* that in pre-Jurassic times, Somaliland formed part of a continent that was continuous with South Arabia and with India. When this continent began to break down in the Jurassic age, the movements associated with the break-down in all probability produced similar results in Somaliland to those produced in other parts of the continent. Several marked features of the main watershed, *e.g.*, Wagger Range and Ashararet Range, doubtless date from this period. Moreover, the tremendous movement, probably folding, which brought about the up-ending or tilting of the Inda Ad slates so that their bedding-planes are at present almost vertical over a wide area, took place certainly before the main series of faults which have affected all the formations from the Jurassic onwards on the north side of the watershed. It is, perhaps, of pre-Jurassic age. North of the main watershed or escarpment, the whole of the Protectorate has been subjected to extreme and long-continued faulting movements that produced the great system of rift valleys extending from the Sabi River south of Lake Nyassa to Aden, and diverging from Aden north-eastwards as the

* Gregory : *Geol. Mag.* 1896, *loc. cit.*

Gulf of Aden, and north-westwards as the Red Sea. This faulting began in post-Eocene times, probably in the Oligocene age when the movements began which ultimately gave rise to the Red Sea, and continued until the beginning of the Pleistocene and Recent age, for every member of the sedimentary series in Somaliland from the Jurassic to the Coastal Limestone has been faulted to a greater or less degree. Moreover, the faulting has not been confined to a series of parallel fractures. There appear, indeed, to be several different systems, but their relations are so complicated that only detailed study of the tectonics of the Protectorate will enable them to be completely unravelled. So far, four main systems have been recognised:—

(*a*) That trending in a direction north-west-south-east. This system is well shown in Western Somaliland, where it has determined the successive parallel scarps of Jurassic limestone forming the ranges of Libaheli, Bur Ad, Karimo, Aga Sur, Eilo, etc., ranges which trend in a direction north-west-south-east (bearing about 310°-130°), and, of course, face north-east. Moreover, as an examination of the map of Somaliland shows that the coast from Bulhar to Zeyla runs in this same direction, it is highly probable that the same system of faults has determined the direction of this part of the coast.

(*b*) That trending in a direction approximately east-west. This system has doubtless been responsible for the east-west trend of the Golis scarp, and the face of its easterly and westerly gneissic extensions, and for the east-west direction of the coast from Bulhar to Berbera.

(*c*) That following a direction north-south. This system has caused the abrupt termination or cutting-off of the Ranges of Western Somaliland, *e.g.*, Sigip, Bur Ad, Bur Madu, etc., and has perhaps determined the western face of the scarp of Siradli, Dud, and Surad Ad, and the low-lying nature of the country at the foot of these scarps.

It may also be responsible for the scarp of the Manna Hills, south-east of Las Gori, which runs in a north and south direction and faces east.

(*d*) That running in a direction east-north-east-west-south-west. According to Wyllie and Smellie, this system determines the north-western face of the Harrar Plateau in Abyssinia, to the south-west of Boramo. It may have caused the east-north-east trend of the coast from Raguda to Mait.

The earliest surface of the Protectorate was formed of granitic and hornblendic gneisses of Archæan age and some quartz and graphitic schists probably of pre-Cambrian age. At some period in the Palæozoic area, there was an invasion of the sea over the eastern part of the country, and the series of slates and limestones of Inda Ad and Goru tug were laid down. As the result of great earth-movements either of pre-Jurassic age or connected with the breakdown of the Gondwana continent, these slates were tilted nearly vertically and intruded by granite. The breaking-down of Gondwanaland followed, and there was an outpouring of basalt lava which is represented by the basalt at the base of the Jurassic Series in Bihendula. At the same time, the western and south-western part of the Protectorate was invaded by a sea which had its greatest extent and depth in Abyssinia and in which Jurassic sediments were laid down. A small branch of this sea extended eastwards as far as Ambal and Karam. At the close of the Jurassic, the sea shallowed and finally disappeared in Somaliland, and, with the advent of the Cretaceous, enormous deposits of sand were formed on the Jurassic sediments and on the surface of part of the present plateau (on the gneisses of the Golis, of the ridges behind Ertoleh, and near Hargeisa). Erosion of the sandstones then took place to a greater or less extent, and was followed by an Eocene marine transgression which was deepest in the east and south-east and gradually shallowed out in the vicinity of Hargeisa. In time, this Eocene sea retreated, leaving large lagoons or inland seas in which great quantities of gypsum and anhydrite, gypseous shales, and some celestite were formed. At the close of the Eocene or during the Oligocene, extensive faulting took place, causing the downthrow of each member of the sedimentary series beginning with the Jurassic, and the ultimate trend of the coast of the Protectorate. This faulting did not take place in one particular period, but occurred at intervals and affected the formation of each age in turn down to the Coastal Limestone. As the area north of the main watershed subsided, thick sandstones and clays were formed in a basin south of the Al Wein Range—the Daban Series—and the faulting which continued after their deposition produced in them a dip to the south, corresponding with the dip of the Gypsum and Eocene strata. This Daban Series was then covered with limestone-and-gneiss conglomerate produced by erosion of the earlier formations. In the later stages of the history of the country, coral reefs which had formed on the shores were elevated by a rise in the level of the coast, and faulted just before the long-continued faulting ceased. As is shown by the presence of coral fringes, shell-banks, and coral platforms some distance from the beaches, the coast is still rising.

III.—ECONOMIC GEOLOGY.

(A) MINERAL OCCURRENCES.

The minerals of industrial value which have so far been found in the Protectorate are the following:—

1. Coal.
2. Lignite.
3. Petroleum.
4. Galena.
5. Salt.
6. Guano.
7. Mica.
8. Beryl.
9. Garnet.
10. Barite.
11. Celestite.
12. Molybdenite.
13. Gypsum.
14. Gold (doubtful).
15. Clay.
16. Talc or soapstone.
17. Marble.
18. Manganese ore.
19. Kerogenous shales.
20. Graphite.
21. Diamonds (doubtful).
22. Sands (doubtful).

1. Coal.—

Coal was found by the writer in the bed and on the side of Hedhed tug, a western tributary of Hodmo tug, which joins the latter some twelve miles south of Ankor. In 1915, samples of coal were sent for analysis to the Imperial Institute by Mr. H. M. O'Byrne, Chief of Customs at Berbera. These purported to come from a solid mass at the foot of Ambal Hill, 53 miles east of Berbera and 30 miles south of Karam, and from the banks of Ambal tug. As, however, subsequent examination by the present writer failed to disclose the presence of any coal in the vicinity of Ambal Hill or in the tug, but showed that the black, in part shaly, carbonaceous material exposed in considerable quantity under the Jurassic limestone in the hill and on the west side of the tug, is kerogenous shale associated with black carbonaceous limestone, it is fairly certain not only that the samples of coal were obtained for Mr. O'Byrne by Somalis, but that they actually came from Hedhed, and that the locality, Ambal Hill and tug, were loosely given for them owing to the unnamed and unexplored condition of this part of the country.

The deposit occurs about three and a quarter miles up Hedhed tug from its junction with Hodmo tug, south-south-west of the junction, in a fairly high tableland of Dubar Sandstone overlain by massive Eocene limestone and much dissected by precipitous ravines. The coal outcrops in a seam of an average thickness of two feet six inches, on both banks and in the bed of the tug. The main outcrop is on the east side of the tug, but an apparently smaller one—smaller, probably, owing to its length being obscured by débris—occurs on the west side. The seam at first sight appears to be horizontal, but it really dips west at the low angle of 5°, so that, after crossing the tug—being only a few inches above the level of the water—it is lost in the west side under the screes and limestone. Moreover, limestone boulders and débris obscure the seam to the south and north, up and down the tug. Both above and below the coal are very fine, somewhat soft, yellowish sandstones. At the chief outcrop the series of beds exposed from the visible base upwards are:—

Yellowish sandstones of unknown thickness.
Coal, 2-3 feet thick.
Whitish sandstones, 2-3 feet thick.
Alternating thin beds of sandstone and calcareous shales, 12 feet thick.
Dark brownish-black carbonaceous shale, 6 feet thick.
Above the shales, massive Eocene limestone over 500 feet thick.

In the section, directly above the dark carbonaceous shales, is a recent conglomerate, which, as it is merely local and formed of ordinary river gravel, is not really a part of the series, but has been deposited on the exposed surface of the outcrop where it has jutted out beneath the limestone.

Under the circumstances, it was impossible to ascertain the true extent of the seam, but it outcrops on the west side for about 100 yards, and the carbonaceous shales

above it extend up the tug for another 100 yards. The upper sandstones are present about 100 yards down the tug as a bed twelve feet thick, but no coal was visible under them.

Samples were taken from about eighteen inches from the exposed surface, and hence can scarcely be regarded as typical of the seam as a whole. They consisted of a dull black substance which might be classified either as a sub-bituminous coal or as a lignite. The structure was somewhat woody, with occasional thin bright bands. The material showed a tendency to split along the bedding planes, but at a distance of eighteen inches from the surface, blocks of considerable size could be hewn from the seam without any sign of splitting. Though, in places, at the surface, there are small lumps and streaks of iron pyrites, this mineral occurs sporadically and in comparatively small amount, and the bulk of the coal is apparently free from it.

The age of the coal is somewhat uncertain owing partly to the fact that the fossils from the overlying limestone have not yet been determined, and partly to the fact that no fossils have yet been found in the Dubar Sandstone, which elsewhere in the tableland underlies the limestone. As it is most probable, however, that the limestone is of Eocene age, and as, elsewhere in the Protectorate, the Dubar Sandstone clearly overlies conformably limestone of Jurassic age, the coal seam series would appear to be between Eocene and Jurassic in age, and to form either the lower part of the Eocene formation or the upper part of the Dubar Sandstone, which there is some reason for thinking to be of Cretaceous age.

The samples were analysed at the Imperial Institute, and the following table gives the results of these analyses, together with corresponding figures obtained from the sample previously sent from Somaliland (in 1915), and for a similar coal now being worked in the Udi district of Nigeria:—

	Present Sample from Somaliland.		Previous Sample from Somaliland	Sub-bituminous coal from Udi Colliery.
	Per cent.		Per cent.	Per cent.
Moisture at 105°C	13·24	14·27	13·01	5·62
Volatile matter	36·87	35·05	35·16	38·18
Fixed Carbon	38·11	37·88	39·78	48·41
Ash	11·78	12·80	12·05	7·79
Sulphur, per cent.	0·65	0·48	0·64	0·76
Calorific value in small calories ...	5404	5070	5661	6969
Colour of ash	pale buff	pale buff	cream	light grey

Using the factor 1·8 to transform small calories into British Thermal Units, the calorific value of the three samples of Somaliland coal are respectively:—

B.T.U. 9,727, 9,126, 10,190.

It must be noted that the figures for the Udi coal were obtained from a sample of the material now being mined, and not from a prospecting sample. As the Somaliland material is really a prospecting sample obtained from the water level without any mining having been done, it is perhaps more reasonable to cite in comparison the results obtained from samples from the Udi district from comparatively undeveloped seams.

According to the Bulletin of the Imperial Institute, the following analyses can be cited:—

	Ofam River (Udi) 2′ seam.	Iyocha Stream (Udi) 5′ 5″ seam.	Iyiku River 1′ 5″ seam.	Okwaga District.		Udi* 2′ 6″—3′ 7½″ seam.
				Inimini River 2′ seam.	Iyorba Stream 3′ 11″ seam.	
Fixed Carbon	42·30	44·88	41 42	43 31	39 49	43·63
Volatile matter	33·82	35·60	37·41	34 26	34·96	32·66
Ash	18·42	14·89	11 64	10 07	14·05	16·79
Moisture	5·46	4·63	9·53	12·36	11·50	6·92
	100·00	100·00	100·00	100 00	100·00	100·00
Sulphur	0·74	0·73	0·54	0·62	0·73	0·87
Calorific value in small calories	5,967	6,437	5,926	5,630	5,494	5,892

* Mineral Survey of Southern Nigeria 1908-09, p. 19.

The Udi coal is stated to be of the sub-bituminous type, and usually of a dull-black appearance, though some of the seams show alternating bands of dull and more lustrous coal. As a rule, it is fairly free from mineral impurity, but occasionally contains nests and films of amorphous clayey matter and pyrites. The coal ignites readily, burns with a bright, steady flame, and gives off only a small amount of smoke. It does not cake or decrepitate on heating. The ash is usually white or light grey and practically free from clinker.

In the notes accompanying the results of analyses, the Imperial Institute remarks: "They (the coals from Somaliland) are all free-burning, show no tendency to coke, and are similar in type and appearance to the coal now being produced at the Udi Colliery in Nigeria, though somewhat inferior to it in heating power. . . . It seems probable that, as seams of coal in Somaliland are opened up, material of higher calorific value and lower ash content will be obtained."

In the light of these facts it appears important that, in the future interests of Somaliland, and in the interests of our knowledge of the coal resources of the Empire, this whole district should be thoroughly examined. The views held before 1914 as to what constituted a coal of economic value have changed to a very large extent, and what with pressure-briquetting and low-temperature carbonisation, it has now been found possible to use commercially coals and lignites which before 1914 were of practically no value. Moreover, it is a matter of experience that the calorific value of samples from coal-seams increases both as the seams are opened up and as other seams are met with at greater depths.

Therefore, search should be made for outcrops of other seams in the district. According to Somali reports—and experience shows that they usually have some basis of truth—there are at least four other localities in the district in which coal occurs, and it is alleged that in at least one of them there is more coal showing than in the seam discovered. The difficulty in regard to these occurrences is that the country south of Ankor as far as Las Dureh is quite unmapped, and even unexplored except by a few tribesmen, so that it is necessary either that native guides should be obtained who know this tract—and there are very few of them—or that traverses should be made of the tugs which dissect the tableland. The latter course is to be recommended, seeing that it would enable the outcrops to be properly located on a fairly reliable topographical plan.

Moreover, as it is unknown whether there are not other seams below the one outcropping, and, as, if there are, there is some prospect of coal of higher calorific value being obtained, the possibility of the occurrence of these should be investigated, if necessary, by boring. As the depth to which it would be necessary to bore would probably not exceed a few hundred feet, and as the rocks met with would be not harder than limestone and sandstone, a boring plant such as is used in Nigeria and elsewhere would be sufficient for the time being.

There is an abundance of excellent water in the ravine in which the seam outcrops, and doubtless equally good water occurs in some of the other ravines. Should it ultimately be found necessary to use timber for an adit, there is a considerable number of large trees in Hodmo tug with boles up to one foot in diameter, suitable for props.

2. Lignite.—

In notes on the official file in Berbera, supplied by the Chief of Customs, and according to Somali reports, an outcrop of coal was stated to occur on the southern slopes of Al Wein Range about 16 miles south-east of Berbera, near a well called Khal Der and in a stream known to the natives as Egmaleh tug.

After considerable difficulty, one outcrop of lignite was discovered by the writer on Egmaleh tug, about a mile north of Khal Der Well, and another about a mile from this one on a bearing 84° along the tug. The latter may be referred to as the East seam, and the former as the West seam. The seams occur in the Daban series of shales, clays and sandstones, which overlie the Gypsum Series, which itself, as already stated, lies conformably on top of the Eocene limestone. The age of the lignite cannot be known definitely until the determination by the palæontologists of the Natural History Museum of the suite of fossils from the Daban beds has been completed, but it is certainly post-Eocene, and hence considerably younger than that of the coal at Hedhed.

East Seam.—The exposure in the face of the cliff which forms the south bank of Egmaleh tug at this spot is as follows—from top to bottom of the cliff:—

12 feet of greyish-white detritus.

6-8 feet of coarse and fine gypseous, sandy beds, in places with coarse sandy conglomerate patches.

1 foot of gypseous chocolate-coloured carbonaceous shales.

4 feet of chocolate-coloured clays separated by thin gypsum veins.

Lignite seam 1-1½ foot thick.

3 feet of chocolate-coloured clays.

The seam extends along the cliff (which faces north) for about three chains. Its average thickness is about fifteen inches; it dips S. 10° E. at an angle of 10°, and strikes E. 10° N.; and it appears to thin out eastwards, though the outcrop becomes obscured by débris. The lignite is jointed in two directions, roughly east-west and north-south, and along the joint planes and bedding-planes are thin plates of selenite. The whole series of clays in fact is gypseous. Though the lignite disappears westwards along the south bank of the tug, the chocolate-coloured carbonaceous shales occur along the bank, so that the lignite is probably beneath them, though not visible. The north bank of the tug has been mostly eroded away.

West Seam.—In dip, strike, thickness of seam, character and sequence of associated beds above and below it, this seam is the same as the East one, and, in all probability, though no proof was obtained, it is merely a part of the latter. The outcrop, however, is traceable for only about twenty yards.

The material from both localities is a lustrous black lignite, that from the west seam splitting readily along the bedding-planes, that from the east weathering at the surface into brownish friable lumps. The West seam appears rather blacker and somewhat harder than the East one. Samples from both outcrops were analysed at the Imperial Institute, and from the results a comparison was made with lignite from Nigeria, with lignite briquettes from Breunsdorf in Germany, and with lignite from Austria. The figures obtained were as follows: —

	Lignite from Somaliland.		Nigerian Lignite from Okpanam.	Breunsdorf Lignite Briquettes.	Austrian Lignite from Aussig.
	West	East			
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture at 105° C	9·68	11·45	12·36	15·67	22·22
Volatile matter	46·51	46·00	47·43	48·28	36 72
Fixed Carbon...	34·49	34·89	31·41	28·59	38·60
Ash	9·32	7·66	8·80	7·46	2·46
	100·00	100·00	100·00	100·00	100·00
Sulphur ... per cent.	6·86	5·42	1·39	3·29	0·69
Calorific value in small calories	5,733	5,211	5,820	5,575	5,603
In B.T.U.	10,319	9,380	—	—	—

The notes accompanying the results state that in all these analyses the amount of moisture recorded is the quantity found in the samples as received at the Institute. The amounts present in the lignites as mined would be considerably higher.

The two Somaliland lignites showed no coking properties, and are noteworthy for their high percentage of sulphur, which, being largely present as gypsum, would seriously affect their value as fuel. It seems probable, however, that when the lignite seams are opened up much of the sulphur in the unweathered material will be found to be present as pyrites, which could probably be removed to a great extent by a suitable method of washing. The fuel would then need briquetting. In other respects, the Somaliland lignite compares fairly well with German lignite briquettes as produced at Breunsdorf for industrial purposes and with Nigerian lignite from Okpanam.

With regard to the sulphur content, it should be noted that the Gypsum Series occurs in Al Wein in great thickness and at a higher level than the top of the outcrop of the Daban Series (the rocks dip at a considerable angle to the south), the floor of the numerous ravines on the south slopes of the range is composed of gypsum, and the tugs of these ravines have all cut through the Daban Series in the vicinity of Al Wein. It is at least possible, therefore, that much of the gypsum in the joint and bedding planes of the lignite has not been produced from pyrites in the latter, but is the result of crystallisation of calcium sulphate in solution in the percolating water of these tugs, and that, therefore, as the seams are opened up and particularly should further seams be discovered at greater depths and at greater distances southwards from Al Wein, the content of gypsum will be smaller. In the lignite samples obtained, no pyrites whatever have been found.

The occurrence of this lignite and the fact that it clearly compares favourably both with Nigerian lignite and with briquettes made from Breunsdorf lignite, render it advisable that a search be made for outcrops in the locality, and that if possible some trial boring be carried out with the object of locating other seams below those found.

The higher calorific value of the west than of the east seam rather suggests that other seams below them may be superior in calorific value to both of them. Should further search for outcrops or by means of a boring plant prove the existence of a considerable quantity of lignite, the material may be made of commercial value by treatment by low-temperature carbonisation or by a briquetting process. The latter process particularly would increase the density and calorific value of the fuel, render it practically impervious to moisture, and eliminate any tendency to disintegrate either when stored or during use. The best method of treatment to be employed could be determined at the Imperial Institute on trial samples of sufficient size. The outcrops are within easy distance of Berbera and transport would present no difficulties.

The statement has been made that the coal at Hedhed is a continuation of the lignite seam at Khal Der. There is no connection whatever between them. The coal at Hedhed is older than the massive Eocene limestone, and is either Lower Eocene or Upper Dubar Sandstone (possibly Cretaceous), whereas the lignite at Khal Der and in Egmaleh tug is certainly post-Eocene.

3. PETROLEUM.—

Petroleum has been known to occur at Dagaha Shabell at the east end of Bihendula Range since 1912, when samples of "a highly bituminous nature" were brought into Berbera by Somalis. In 1914, as the result of a report on three samples by the Imperial Institute, and of a further report on samples collected in 1913 by Mr. H. A. Byatt,* who himself visited the locality, it was decided by the Colonial Office to have an expert examination made of the occurrence. Since this decision there have been three authoritative reports issued on the Dagaha Shabell Field, viz.: —

1. By Mr. H. T. Burls, in 1914, for the Colonial Office. The conclusion come to in this report was that "the existence of a thickness of at least 20 feet of shale saturated with rock oil at the base of a series of shales and sandstones, 500 feet in thickness, some of which are bituminous, render(s) it in my opinion most advisable to sink test wells to prove the extent and probable yield of a deposit that may develop into a valuable oilfield."

2. By Mr. Beeby-Thompson and Dr. Ball in 1918. This report was the outcome of a request made by His Majesty's Government to the High Commissioner of Egypt that he would arrange for a careful investigation to be made of certain oil indications in Somaliland, with a view to determining whether the indications were those of an oilfield capable of commercial development. The report was published in Cairo in 1918.

After careful geological examination and detailed mapping of the vicinity of the occurrence, Mr. Beeby-Thompson and Dr. Ball came to the following conclusions: —

> "We have no hesitation in advising drilling operations at Daga Shabell in order to test the commercial worth of the deposits. Although the geological structure of the district does not conform with conventional anticlinal ideas, the essential conditions for the formation, retention and concentration of petroleum exist so obviously that they could not be ignored by the most pessimistic observer. So far, oil indications have only been located over an area of about fifty acres, but there is no reason to doubt that these outcropping oil-beds continue for a considerable distance to the south and south-west; and although they will be struck at increasing depths, the inclination of the beds is so gentle that they can be reached by the drill for at least two miles from the outcrop."

After reviewing the situation and summarising the favourable features, Mr. Beeby-Thompson concludes:

> "The uncertainties already mentioned can only be removed by drilling. That oil will be found in some quantity is quite certain, and that the quality will be good is equally sure, but the drill alone will demonstrate the thickness of the series and the area of saturation."

3. By Drs. Wyllie and Smellie, of the Anglo-Persian Oil Company, in 1920.

In 1920, the Anglo-Persian Oil Company, becoming interested in the possibility of the occurrence of an oilfield on a large commercial scale in Somaliland, sent two of their geologists, Drs. Wyllie and Smellie, to make an investigation of the prospects of the occurrence of petroleum in the Protectorate. The area examined by them during the course of seven months was the central coastal district enclosed (on the map) by lines drawn from Zeyla to Meragelleh, from Meragelleh through Hargeisa and the base of the main scarp to Las Dureh, from Las Dureh to Ankor, and from Ankor through Berbera to Zeyla. The country to the east of Ankor and from the top of the scarp southwards to Abyssinia was not examined. Particular attention was

* Now Sir H. A. Byatt.

devoted to Dagaha Shabell, and the stratigraphical geology of the whole area outlined was studied in order that the geology of Dagaha Shabell itself could be examined in proper perspective. As a result, the conclusions arrived at, both as to the geology of the occurrence and as to its possibilities, were in some respects different from those of Mr. Beeby-Thompson. In order to clarify the present position with regard to the field, it will be as well to set out briefly the main statements in each of the two reports.

1. According to Mr. Beeby-Thompson, the rocks exposed in and around the oilfield can be classified into the following four well-marked groups:—

(i) Alluvial deposits (recent sand and gravel).

(ii) A Limestone-Conglomerate series, consisting of beds of coarse limestone conglomerates alternating with sandstones (Miocene?).

(iii) Brown sandstones without clays (Jurassic).

(iv) The Shabell Series, consisting of alternations of clays and sandstones (Jurassic), some of the lower beds of which contain oil.

(i) The Alluvial Deposits comprise older limestone-gravels which cap the hills, and younger sands and gravels which cover a large proportion of the lower country.

(ii) The Limestone Conglomerate Series comprises thick strata of conglomerates consisting mainly of hard limestone pebbles and boulders somewhat loosely set in a sandy or calcareous matrix, alternating with whitish and yellowish sandstones of a rather friable nature. In some places the limestone pebbles and boulders are mixed with others composed of igneous and metamorphic rocks. The deposition of the series dates back at least to Younger Tertiary times and a Miocene age is provisionally suggested.

At some points along lines of fault, the limestone-conglomerate beds have been transformed into hard breccias by combined pressure and the action of mineral solutions circulating in the fault plane. The rocks called Daga Shabell, from which the oilfield has been named, are conspicuous upstanding masses of hardened fault-breccia formed in this way; the hardening appears to have been principally due to deposition of siliceous and calcareous matter between the fragments.

(iii) The Brown Sandstones without Clays are a series of well-bedded rocks which are faulted down against the Shabell Series forming the line of hills bounding the oilfield to the north-east. They are well marked off in the field from the sandstones which occur in the Shabell Series by their colour and by the absence of any intercalated clays; but it is quite likely that they are really the uppermost beds of a single great group comprising both them and the Shabell Series. The clays in the latter become noticeably less and less prominent the higher one ascends, and possibly there is a continuous conformable passage from the Shabell Series upwards into the Brown Sandstones without Clays. It seems most likely that the beds are Jurassic, corresponding with the sandstones overlying comformably the Jurassic limestones of the Bihendula hills further west.

(iv) The Shabell Series forms the lowest member of the geological column visible in the immediate neighbourhood of the oilfield, and is a great series of alternations of red and purple clays with white, brown and greenish sands and sandstones. . . . By far the most strongly-marked feature of the lower beds is the abundance of red and purple clays. As one ascends in the series, the clays diminish in abundance, and the sandstones increase in thickness, possibly passing gradually into the "Brown Sandstones without Clays." . . . Where the Shabell Series is faulted up against the limestone-conglomerates, the sandstone beds have generally been hardened to quartzite, frequently with an increase in the amount of iron oxide present, giving the rock a deep reddish-brown colour. Oil-bearing sands and sandstones occur at intervals in the lowest half of the series, from the lowest point exposed up to a geological horizon some 850 feet higher.

As regards the age of the Shabell Series, the same remarks apply as in the case of the "Brown Sandstones without Clays." The beds are most probably Jurassic.

The oilfield is sharply limited on the north-east and north-west by faults which have thrown up the oil-bearing Shabell Series against younger rocks. There are three main faults. One, which shows the greatest movement, crosses the gorge to the north of the Daga Shabell Rocks, throwing down the limestone-conglomerates to the north. Another extends from the former past Daga Shabell and follows a sinuous course south-westward along the flanks of the hills; this fault has let down the conglomerates to the north-west, and has thrown up the Shabell Series to the south-east. The third follows the flanks of the hills in a south-easterly direction and has only been sufficient to throw down the "Brown Sandstones without Clays" alongside the Shabell Series.

The general effect of the earth-movements, which have resulted in the tilting and faulting of the rocks, is to bring up the lowest beds of the Shabell Series to the surface at the most northerly point of the oilfield, where two of the main faults converge to meet the third one, and it was near this point that the seepage of oil from the beds occurred which led to the discovery of the field.

With reference to the question of the source of the oil, Mr. Beeby-Thompson considers three possible ways:—

(*a*) The oil may be a product of migration from deeper unexposed strata.

(*b*) The contained oil may be the result of chemical action arising from local circumstances.

(*c*) The oil may be indigenous to the strata in which it now occurs, and be derived from organic matter contained in the beds.

In regard to (*a*), he states that the fact that oil is mainly concentrated where the three major faults converge naturally arouses the suspicion that the oil has migrated upwards in the highly fractured area of that region, but the absence of all indications of oil in the adjacent porous conglomerate and sandstone series speaks against this hypothesis; and further, were it true, it is exceedingly unlikely that no traces would have been found of its existence along the disturbed fault—zones that cut off the Shabell Series.

Dismissing (*b*) as, under the circumstances, improbable, he holds that (*c*) appears most satisfactorily to explain the origin of the oil, and states that one strong argument foi considering the deeper unexposed beds of the Shabell Series to be the main oil-bearing series is found in the fact that impregnation of the upper sands is observable only in the vicinity of the minor fault already alluded to. He adds that these upper sands appear to have derived their oil-contents through the medium of this fault from a deeper source, which it is reasonable to conclude is the lower Shabell group, whose upper horizons are alone visible.

2. Drs. Wyllie and Smellie, after an investigation of the stratigraphy not only of the Dagaha Shabell neighbourhood, but of the country as far east as Ambal and as far west as Eilo Range and Meragelleh—*i.e.*, of a much wider area than that examined by Mr. Beeby-Thompson—arrived at the following results:—

They separated off as Dubar Sandstone a sandstone series lying mostly conformably on top of the Jurassic limestone, and, in places, below the Eocene limestone.

A point of great stratigraphical importance, they were the first to recognise the presence at Daban and on the southern slopes of Al Wein, near Khal Der well, of the series of alternating greenish and red sandstones and purplish, green and chocolate-coloured clays called conveniently the Daban Series. Owing probably to the limited area examined by Mr. Beeby-Thompson, he failed to note not only the stratigraphical relations and unusual character of these beds, but even their existence. As already mentioned, this series contains thick beds of brown and red sandstone practically indistinguishable from Dubar Sandstone except by consideration of the associated beds.

They hold that the Shabell Series of Beeby-Thompson is, in fact, not of the same age as the Dubar Sandstone, and not of Jurassic, but of Kainozoic age. They state that the Dubar Sandstone was found and examined over a wide area from Dubar to Ambal, and nothing comparable with " Shabell " beds was found throughout its whole thickness, and, indeed, that with the exception of a 20 feet band of mudstone at Biyo Dader and some sandy shales at Ambal, no argillaceous sediments were found in this series. They consider that the " Shabell " beds represent a marginal or shoreward facies of the Daban beds, and that it follows that the earlier formations had already been faulted and eroded before the Daban-Shabell period started.

Of the " Brown Sandstones without Clays," which in their geological map is marked off by faults as a hexagonal area of sandstone east of Dagaha Shabell, and which Beeby-Thompson and Ball regard as of Jurassic (Dubar?) age and as the formation into which the Shabell Series probably passes gradually upwards, they state that they are by no means satisfied that it does not really belong to the Dubar Sandstone. Along the fault which bounds it on the north side are numerous masses of what appears to be solid Eocene limestone and one small mass of gypsum. According to them the direct evidence is not sufficient to prove that these erratic masses are not remnants of an Eocene limestone and gypsum cap which lay on top of a horst of Dubar Sandstone. But, they assert, seeing that elsewhere along this line of fault, enormous boulders of Eocene limestone are definitely seen to form part of the conglomerates (Dagaha Shabell Rock itself), there is, perhaps, a balance of reason in favour of regarding the sandstone mass as belonging to the uppermost " Shabell " beds.

They believe that the rock called Dagaha Shabell is, in the main, a solid mass of Eocene limestone and not a sheared conglomerate as interpreted by Messrs. Beeby-Thompson and Ball. Similar large masses of Eocene limestone can be seen along the Agagwein Ridge.

With regard to the origin of the oil, Drs. Wyllie and Smellie believe that the petroleum is derived from the shales and mudstones of the underlying Jurassic. The " Shabell " beds being an overlapping series laid down in an irregular basin bounded mainly by faults, it was found by them impossible to predict what strata would be found below the lowest exposed beds, which are the petroliferous sandstones and clays. But that the Bihendula beds—Jurassic limestone and carbonaceous shales—extend eastwards underneath Dagaha Shabell is supported by the presence of the small Jurassic outlier at Ida Kabeita, and, adopting the view that Jurassic beds are the source of the petroleum, it must be granted that those beds lie uneroded below the Dagaha Shabell seepage, and that probably some thickness of Dubar Sandstone covers the Jurassic. Moreover, if it can be assumed that the fault-plane has been adequately sealed by the plastic clays of the " Shabell " beds, then a concentration of oil might be expected either in the Shabell sandstones outcropping underground against the fault, or in the Dubar Sandstone which probably underlies them.

They profess to be unwilling to make this latter assumption, because they regard the degree of mineralisation shown by the sandstones along the east-west fault from Dagaha Shabell westwards as evidence of the free circulation of mineralising solutions along the fault-plane, and as indicating a high degree of probability, not only that a mobile oil could also find a passage, but that the degree of mineralisation has been produced by solutions attending the escape of the oil.

They further state that the Dagaha Shabell seepage has had an erratic and a declining career. Of three shafts, A, B and C, put down by Messrs. Thompson and Ball, they assert that these geologists reported a yield of from two to three gallons per day, mostly from shaft B; that shaft B continued to yield oil for a time, until it was found full of water with only a thin scum of oil. At the time of their visit in 1920, they state, shaft B had ceased to yield, and shaft C never apparently yielded much. Shaft A was re-excavated under their supervision, but five months after digging, the pit was found destitute of oil, with the exception of slight sweatings.

Their final conclusions were:—

(i) With regard to possibilities of accumulation of oil in beds which do not come near the surface, but terminate underground against the fault, large accumulations are highly improbable, though small quantities may still be found.

(ii) No area of promise besides Dagaha Shabell was discovered.

(iii) The amount of petroleum to be obtained by drilling is, in their estimation, so limited that the expenditure involved in transporting and running a standard drilling rig cannot be recommended (to the Company).

(iv) In view of the limited possibilities at Dagaha Shabell, the best policy would be—in the event of a test being considered advisable—to test by means of a portable rig capable of reaching 600-800 feet. This would save expenses, would expose the strata in which the greatest results may be expected, and would in any event decide whether the field is worthy of further attention.

In the light of the reports by Burls, Beeby-Thompson and Ball, and Wyllie and Smellie, and as the present writer was primarily engaged in an investigation of the mineral resources of the Protectorate with special reference to minerals other than petroleum, there was no necessity to make another full examination of and report on the oilfield; but in view of the considerable differences of opinion between the authorities advantage was taken of an opportunity to make a brief inspection of the field, and a short statement of the conclusions arrived at and the facts observed will be of some value. Having examined a much larger area of the Protectorate than even Drs. Wyllie and Smellie—an area stretching from Somadu in the west to the Italian frontier in the east—the writer has no hesitation in agreeing in the main with the interpretation of the geology of Dagaha Shabell as set out by Wyllie and Smellie. The Shabell Series consisting of alternating greenish and red sandstones and purplish, green and chocolate-coloured clays exposed in the shafts and their vicinity are markedly distinct from either the Jurassic beds or the Dubar Sandstone, and this fact would have been realised by Beeby-Thompson and Ball had they, in their investigation of the oilfield, examined a wider tract of country than the Berbera-Bihendula track and the immediate neighbourhood of Dagaha Shabell. The writer has examined the Dubar Sandstone (and, where existing, the Jurassic) beds from Kabri Bahr in the west to

Las Gori in the east, and with the exceptions noted by Wyllie and Smellie and some sandy-clay beds on the track just west of Biyo Gulan (at the south end of Jirba Range), he has nowhere found any green, purplish or chocolate-coloured clays in them, whereas in the Daban Series just north of Khal Der where the northern edges of the series outcrop on the slopes of Al Wein, the green and chocolate-coloured clays are a pronounced and characteristic feature of the Daban Series. The latter, overlying the Eocene and Gypsum Series without any evidence of a thrust are undoubtedly younger than the Eocene, though their true age will not be known until the determination of the fossils collected has been completed.

With regard to Dagaha Shabell rock itself, the writer, having examined numerous Eocene limestone scarps in the Golis and elsewhere, is of opinion that it is part of a solid mass of Eocene limestone and not a sheared conglomerate. Undoubtedly on the weathered surfaces the rock exhibits a nodular or an indistinct conglomeratic structure, which is due to denser, yellower and more or less rounded portions of limestone being surrounded by indistinct shells of looser and greyer limestone. The appearance in the most advanced stage seen is somewhat similar to that produced by spheroidal weathering in basalts. If the Dagaha Shabell rock alone exhibited the structure, there would certainly be room for doubt whether it was not a limestone conglomerate. At many other places, however, notably on top of the Golis scarp south-west of Sheikh, and on the scarp at Geba Geba Pass, limestone showing the structure clearly forms the top of the limestone scarp, and as far as could be seen, the indistinctly nodular facies gradually merges into the massive Eocene limestone without any trace of an unconformity. Doubtless, examination of sections of the nodules and of the "shelly" portions will settle whether a true matrix is present or not, but even should a conglomerate be actually present on top of the Golis and Geba Geba limestone, it appears certain that the Dagaha Shabell rock is merely a mass broken off from a normal Eocene scarp and is not a sheared conglomerate *in situ*. It occurs in the ordinary conglomerate and may be an erratic.

The "Brown Sandstones without Clays" present a problem difficult of solution. Lithologically they are scarcely distinguishable from the Dubar Sandstone, and the sandstones exposed at Khal Der belonging clearly to the Daban Series are equally indistinguishable from it. They form an hexagonal mass bounded, most clearly on the north and west, by faults. Along the fault boundary on the north side are masses of Eocene limestone and one small mass of gypsum, and as the succession in many localities elsewhere is Eocene limestone surmounted by gypsum beds and underlain by Dubar Sandstone, it would appear that particularly near these two faults, the sandstone is really Dubar Sandstone. On the other hand, the limestone above the sandstone is a mass similar to but smaller than the Dagaha Shabell rock and may, therefore, be regarded as of the same origin. Moreover, exposed in the east cliff facing west and south-west, are whitish arkose sandstones, and farther east, chocolate-coloured sandstones run underneath the cliff and under the arkose sandstones. On the west cliff, which belongs to the Daban Series, there are also, in ascending order, chocolate-coloured and greenish sandstones, whitish arkose, red, slaty, yellow, and white sandstones, and finally limestone conglomerates containing masses (erratics probably) of Eocene limestone. There is, on the whole, a noticeable correspondence in the sequence in both cliffs, and on the east cliff the sandstone bands near the top are identical in all respects with the yellow sandstone beds exposed just north of Khal Der. The balance of evidence, therefore, is in favour of the "Brown Sandstones without Clays" being part of the Daban Series, and of Kainozoic and not of Jurassic age.

Origin of the Petroleum.—The occurrence of the oil in the clays and sandstones of the Daban Series suggests two possible modes of origin:—

(1) That it has been derived from carbonaceous material in the Daban beds themselves.

(2) That it has been derived from a series below the Daban beds at Dagaha Shabell, and what now appears is escaping upwards along a fault-plane.

1. The Daban Series undoubtedly contains abundant carbonaceous material at the horizon outcropping at Khal Der, where both lignite seams and chocolate-coloured carbonaceous clays occur. Moreover, to judge from the average dip of the beds of the series and their extension along the direction of the dip, the thickness of the series must be over 10,000 feet, and very possibly other carbonaceous strata occur at lower levels than those found. So far as has been observed, however, these carbonaceous beds show no bituminous or kerogenous characters, and the structure of the series shows no favourable indication of the occurrence of oil in it.

2. That the Bihendula Jurassic Series of limestone and black carbonaceous shales does extend eastwards under Dagaha Shabell is, as pointed out by Wyllie and Smellie,

supported by the occurrence of the small Jurassic outlier at Ida Kabeita, and other remains of Jurassic beds occur farther east at Ambal and Bihen Gaha, in both cases with black carbonaceous shales underlying limestone. In the opinion of the writer, therefore, the more feasible explanation of the presence of the oil is that under the Daban Series at Dagaha Shabell occurs the Jurassic Series containing, at least originally, carbonaceous or kerogenous shales. Distillation of these shales gave rise to petroleum which has been kept in the Dubar Sandstone overlying the Jurassic. Subsequent faulting brought about a means of escape for the oil along the fault-plane, but the Daban clays above have more or less sealed this fault-plane, and the oil which is now escaping is the small portion which has percolated through the clays. The distillation of the shale has possibly been brought about by the intrusion into them of dolerite dykes or sills. Wyllie and Smellie have mentioned the presence at the base of the Jurassic in Bihendula of a bed of basaltic lava. The present writer, however, during an examination of the Jurassic outcrops at Daba Dulla in Western Somaliland, found the black carbonaceous shales that underlay the limestone intruded by a dolerite dyke which had violently dislocated the strata, had more or less baked and bleached them and had produced in them traces of secondary minerals. South-east of Hemal other black shales under Jurassic limestone were found to have been similarly affected. The basalt at the base of the Jurassic in Bihendula may be, as Wyllie and Smellie consider, a lava, or it may be a sill, especially as the evidence of successive flows in the outcrop was by no means clear. If it is a lava, it is, with one exception, the only occurrence* of pre-Jurassic or early Jurassic basalt noted in the Protectorate and it can have had no effect on the production of the oil. If it is a sill, then it is probably of the same age as the basaltic dykes at Daba Dulla and Hemal.

Faulting has produced the essentials of an anticlinal structure in the oilfield, and there is no doubt some thickness of Dubar Sandstone overlying the Jurassic which has acted as a reservoir for the distilled fluid, otherwise the latter would have all escaped before the Daban beds were laid down.

As regards the free circulation of the oil along the fault-plane and the statement of Wyllie and Smellie that the high degree of mineralisation was probably caused by the escape of oil from below, the writer is unable to agree with the amount of importance attached to them. The degree of mineralisation is by no means greater than is observable, say, in the sandstones north of Khal Der, where there is no suspicion or suggestion of the occurrence of oil, and one would normally expect that, as a fault-plane is always to some extent a water-channel, the degree of mineralisation could quite feasibly be produced by ordinary circulating ferruginous water. The mineralisation *may* have been caused by the escape of oil, but there is no more reason for accepting this view than that it has been caused by these circulating surface solutions. Moreover, if it were due to the escape of oil, it is fairly certain that some traces of oil—some solid residuum—would have been left along the channel equally with the ferruginous impregnation, yet not a trace—seepage or residuum—could be found anywhere along the line of the north fault through the sandstones. It is probable, that, owing to the sealing of the fault by the Daban Clays, it is only at a certain spot that any oil can seep through, and that the present shafts mark this spot.

With reference to the statement of Wyllie and Smellie that the seepage has had an erratic and a declining career, and giving the information obtained by them as to the character of the wells, the writer found the facts in 1923 somewhat different from those found by the former in 1920. Owing to the fact that the holder of the oil concession has not manned his concession, and that, consequently, no work or observations have been carried out at the occurrence since 1920, the actual history of the wells or shafts since that date is unknown. In 1923, however, oil was certainly found in two of the shafts:—

(1) In the shaft (22 feet deep) put down by Wyllie and Smellie, oil now occurs for a depth of two feet and is being periodically carried away by camelmen. This was the shaft about which they stated that, five months after digging, it was found destitute of oil with the exception of slight sweatings on the walls.

(2) In the shaft next to it to the north (34 feet deep) oil now occurs (with a little water due to rain) for a depth of two feet.

Owing to the lack of any record since 1920, no estimate of the rate of seepage is possible.

Without doubt, as the wells (or shafts) are in the tug valley itself, and as the tug is occasionally a fast flowing stream, the oil has been from time to time floated out, and the wells have been partly filled with alluvium, so that, unless they are cleaned out again, a considerable time may elapse before any oil is again visible in them.

* Another, however, is stated by Wyllie and Smellie to have been found by them under the Jurassic at Bihen Gaha Pass.

Wyllie and Smellie state that so far as the seepage can be taken as an index of the amount of petroleum present in the sands which come to, or near, the surface, that amount can only be very small. The vital questions, however, are how far this seepage *can* be taken as an index and whether the bulk of the oil does not exist in sands which do not come to, or near, the surface. The quantity of seepage—on the hypothesis (with which Wyllie and Smellie are in accord) that the oil has originated from the kerogenous shales of the Jurassic Series—depends chiefly on the amount of oil present in the reservoir sands and on the degree to which the clays of the Daban Series have sealed the fault-plane, and as it is probable that this sealing has been effective, the value of this seepage as an indication of the amount of oil obtainable by boring may be very small.

It is believed, on reasonable grounds, that the beds underlying the petroliferous clays and sandstones are Daban and Dubar Sandstones, which act as a reservoir for the oil, and the Jurassic Series from which the oil was distilled. What, however, is the extent of these series and consequently what is the size of the oilfield can only be surmised.

In view (1) of the lack of knowledge of the beds that have given rise to the oil, the beds that at present actually contain it, their extent and thickness,

(2) Of the continual seepage of appreciable quantities of oil and the fact that the clays of the Daban Series can act as a seal to the fault-plane,

(3) Of the fact that boring to prove whether oil exists in considerable quantities would require at first to be carried out only to a depth of between 600-800 feet in sandstones, shales and clays,

(4) Of the statement even of Wyllie and Smellie that boring to this extent on the spot indicated would explore the strata in which the greatest results may be expected, and would in any event decide whether the field is worthy of attention;

in view of these considerations, the writer is strongly of opinion that this boring should be carried out. Where so much doubt exists, where such positive evidence of the existence of oil is present, and where the cost of boring will be, comparatively, so small, it is of little value to devote attention to possible explanations and to hypotheses which, under present circumstances, cannot be tested by evidence. What are necessary are further facts and these can only be obtained by boring. If the oil has originated from Jurassic shales, then, to judge from the size of the outcrops of these beds at present in existence and in consideration of the probability that only a branch of the Jurassic sea extended into the central part of the "Guban," the extent of the oilfield would appear to be limited. On the other hand, as Jurassic shales have been found as far east as Ambal and Bihen Gaha, as Jurassic limestones occur within eight miles of the coast near Dubriat, and as evidence exists that the Jurassic rocks between Lower Sheikh and Berbera were formerly, before erosion, spread over a fairly wide area, it is possible that those unexposed and covered up by Daban beds are also of considerable extent, seeing that they have been largely preserved from erosion.

The present concession for boring for oil in the Dagaha Shabell neighbourhood, should, in default of work being promptly done on the field, be terminated on the expiry of the present period of extension. The conditions attaching to the grant of a concession particularly for oil exploration or development include, or should include, that work should be regularly carried out on the property. If this work is not carried out regularly, the grant should be withdrawn so that any other person or party desirous of obtaining the concession and willing and able to observe the conditions may be permitted to do so. As matters at present stand with reference to the Dagaha Shabell occurrence, no development work of any consequence whatever has been done by the present holder of the concession—despite several periods of extension of the grant—and the fact that the concession is held, effectually prevents anyone else from doing any work on the property. All necessary preliminary geological work has been carried out, suitable sites for the preliminary bores have been fixed, even estimates of the cost of machinery and of the actual boring have been prepared, and all that is now needed is the placing of the machinery on the ground and the services of a qualified superintendent of the boring machinery and operations. Experience elsewhere shows that, where a genuine desire exists to proceed with the work, there is no difficulty in obtaining such a man, and even if there were, it is possible in these days to have the whole of the work carried out by boring contractors, who provide their own machinery and their own engineering staff. Undoubtedly, after the receipt of a concession, some little time is usually required before operations can be begun, but when a genuine desire to proceed with the work and the necessary capital exist, the period of the concession has not elapsed before tangible progress has been made.

Petroleum Indications Elsewhere.—

The work done confirms the view of Wyllie and Smellie that with the exception of Dagaha Shabell, no place in the Protectorate so far examined

offers any prospect of the existence of an oilfield. An anticlinal structure was found in three places: —

(1) In Abassa Dadera tug, north of Boramo.

(2) In Ambal Hill, south of Karam.

(3) At Biyu Dader.

1. In Abassa Dadera tug the Jurassic limestone forming the bank of the tug is folded for a very short distance, the dip at one spot being 25° in a direction S. 30° W. and at another a few yards farther on, 23° in a direction N. 15° E. This folding, however, appears to be merely local, and though the tug has cut through the rock at right angles to the axis for a considerable depth, no trace of oil was to be seen.

2. Ambal Hill at first sight appears to be a dome, but close examination shows that the west side is marked by a considerable thickness of sand, and as, farther north, two other similar Jurassic hills were clearly faulted on the west side, it is most probable that in Ambal Hill also the west side is faulted, but the fault is concealed by the sand.

3. At Biyu Dader, to quote Wyllie and Smellie, " the evidence of true folding is very strong, a definite anticlinal arch being traceable for about four miles in an east-south-east direction with dips of 10° to the north-east and 10°-12° to the south-west." Though the anticline, however, is largely broken down by faults, no vestige of oil or of oil residuum was to be found in the vicinity.

In Western Somaliland, where the greatest development of the Jurassic rocks is present, in spite of the fact that they are underlain by kerogenous shales, the sediments have no suitable cover, they rest in a floor of granite and hornblende gneiss either directly or with an intervening friable sandstone of no great thickness; they occur in faulted blocks having a steep scarp generally facing north-east, and a dip 25°-30° to the south-west. No indications of oil could be found in any scarp examined, and, though every well on the whole trek through the region was carefully examined, no oil films were discovered. Even at Meragelleh, where a large thickness of kerogenous shales underlies the limestone, and the beds are in places flat or nearly so, there is no cover to the rocks suitable for containing oil, and there is evidence that the gneissic floor is not far below the surface. The large escarpments of Bur Ad, Libaheli, Aga Sur, Eilo, Karimo, etc., all rest on a gneissic floor which is visible at many spots. Similar remarks apply to the exposures in the Central District, though in this district the overlying Dubar Sandstone is still preserved in several localities. At Ambal Hill, not only is there a lack of suitable cover to the Jurassic rocks, but there are no indications in the tug, in the wells, or elsewhere of any oil occurrence. At Bihen Gaha, the Jurassic Series occurs in a similar way to that in Western Somaliland, though both kerogenous shales and black fœtid limestones form the base. In Eastern Somaliland, the Jurassic is not present, the sedimentary rocks are either old, probably Palæozoic, slates with upturned edges, or Eocene and later limestones with neither suitable structure for the occurrence of oil nor any indications of its presence. The east-south-eastern, south-eastern and southern portions of the Protectorate were not examined. There are occasional rumours of oil indications having been found in the Baran District near the Italian frontier, but the hills and ridges in the south-east appear to be formed, at least in part, of Eocene limestone with overlying gypsum beds. Whether any limestone of older age, or any structures favourable for the occurrence of oil exist, there is at present no evidence to show.

Of the country south-east of Boramo and south of Hargeisa, nothing at all is known. The presence of Jurassic limestone ridges a mile or two south-east, south-west, and south of Boramo, indicate that this limestone extends for a considerable distance farther south than was apparently known to Wyllie and Smellie. According to the latter, Dr. Barnum Brown, of the Anglo-American Oil Company, was understood to believe that the Jurassic beds offered possibilities of oil in the down-faulted area north of Jig-Jiga where they are suitably covered. Whether the Jurassic in the vicinity of Boramo is connected to the south and south-west with the Jig-Jiga limestone, and whether, in that event, there are possibilities of oil in the intervening country are questions outside the scope of the present work.

The oil from Dagaha Shabell has been analysed by the Imperial Institute, by Sir Bovington-Redwood and at the Egyptian Government Analytical Laboratory, and some results are given in Mr. Beeby-Thompson's report. It is to be noted, however, that all the samples of oil analysed were obtained from near the surface and, having been exposed to the atmosphere for an unknown length of time, were necessarily of higher density or contained a smaller proportion of the more volatile constituents than may be expected from oil that has yet to be obtained from the sands at greater depths.

4. Galena.—

Samples of galena collected by Somalis were sent from Berbera to the Imperial Institute for analysis in 1920, but, beyond the fact that they had been obtained in the Warsangeli District in the north-east of the Protectorate, and the results of the analyses, no reliable information about the occurrence was obtainable. By means of enquiries from the District Commissioner at Las Gori and with the help of local guides and tribesmen, two occurrences of the mineral were found by the writer:—

(1) At Unkah, about $1\frac{1}{4}$ miles north-north-west (bearing 336°) of Inda Ad, south-east of Las Gori.

(2) At Kul, about 13 miles east of Inda Ad, and about 2 miles up the Kul tug, which flows from the Eocene limestone escarpment.

Unkah is about two camel-treks and Kul about three south-east of Las Gori, and Kul is about 16 miles south of Ras Adaddo on the coast.

(1) At Unkah, the galena was found on the top of a small saddle just to the right of the track from Inda Ad and on the site of a small Somali karia (collection of huts). It appears to have been first obtained by a Somali woman engaged in erecting a hut. Under the existing conditions as regards time, labour and implements, and, on account of the presence of the karia, it was not possible to open out the occurrence to any appreciable extent, but, with considerable difficulty, a hole was sunk to a depth of about two feet, a trench was cut along the strike of the slates for about fifteen feet, and a crosscut about eighteen inches wide was put in across the strike. From this amount of work it was apparent that the galena occurs in the old series of (probably) Palæozoic slates, more or less sporadically as slugs between the laminæ of slate and in the laminæ themselves. It is associated with chalcedonic quartz and with barite. The mineralisation extends parallel to the strike of the slates for a proved length of about fifteen feet, for a proved width of about eighteen inches and for an unknown depth. To the north-west and to the south-east of the karia, the lode or vein was cut off by a dyke of a grey, very much carbonated and decomposed rock of a porphyritic character, standing up as small bluffs. No solid mass of galena was seen, but of course the amount of work done on the deposit was quite insufficient to determine accurately its value or possibilities. An effort was made to find the continuation of the lode to the north-west and to the south-east beyond the intrusive bluffs, but, owing to the surface being obscured by débris and undergrowth, it was not possible in the time available to ascertain whether it continued on or not.

Specimens of the ore were collected and were assayed at the Imperial Institute. The results were:—

		Per cent.
Pb	... ...	77·97
Au	... ...	Nil
Ag	... ...	1 oz. 15 dwts. 15 grains per ton.

The amount of lead present is quite satisfactory from a commercial standpoint, but the amount of silver is not large enough to render the metal a valuable bye-product.

(2) At Kul, the galena occurs near the base of the Eocene limestone scarp in a small hill composed of slates similar to those at Unkah. It was originally found more than twenty years ago, apparently by Colonel Ashby in a small hole near the bank of Kul tug. In the hole, the mineral occurs in association with barite along a cleavage plane in the slates, in part as slugs, in part as small crystals, strings and veinlets in the barite. On examination of the hill—which was rendered difficult by continuous rain over a period of five days—it was found that the galena and associated barite could be traced from one side of the hill over the top to the other side owing to the fact that the minerals form a well-defined white vein and that numerous fragments of galena, and of barite enclosing galena, lie scattered over the surface. The vein is from three to four feet in thickness and consists in places of two, in places of three parallel veinlets which occupy cleavage cracks in the slate running in a north-easterly direction. On each side of the veinlets, the slate is ferruginous. The strike of the slates is north-north-west—south-south-east, the direction of dip is about N. 82° E. and the amount of dip varies between 35° and 40°. Several small holes had previously been sunk along the course of the main vein, probably also by Colonel Ashby, but these were so overgrown by scrub that, under the existing conditions, little information could be obtained from them. Though a few crystals were got in the first hole, the galena of the main vein is largely a finely granular, somewhat friable variety, in patches, strings, or streaks in the barite. The occurrence of the mineral, however, so far as could be seen, is sporadic, no large deposit was met with, and the veins contain, probably, too small an amount of ore to be of much value in themselves.

An analysis of a sample chipped from the barite mixture, but containing a considerable amount of barite, was made at the Imperial Institute, with the following results:—

	...	Per cent.
Pb	... ...	39·86
Au	... ...	Nil
Ag	... ...	1 oz. 11 dwts. 16 grains per ton.

The low percentage of lead present is, of course, due to the amount of associated barite in the sample, and it is probable that had the lead ore only been assayed the percentage of silver obtained would have been higher.

In view of the above facts and the comparative inaccessibility of the locality, the occurrence is of little economic importance except as an indication of mineralisation of the country, of the presence of galena over a wide area, and of the presence of that particular variety of galena—the finely granular or indistinctly crystallised—which, according to experience elsewhere, usually contains a greater proportion of silver than the coarsely crystalline material. The occurrence is somewhat similar to that at Unkah, but at Unkah there is more galena and much less barite, and the locality is readily accessible.

The deposits are probably to be classified amongst the so-called disseminated lead-ore bodies which are the result of the abstraction of lead from waters circulating along channels and bedding-planes or from solutions rising under hydrostatic pressure along more or less vertical channels.

The significance of the discovery of these deposits is that they indicate the possibility of the presence of sulphide ores in the Black Slate Series. This series has not hitherto been known to occur in the Protectorate, and in no other part of the latter so far examined, except at Dobo in Western Somaliland where molybdenite occurs in granite pegmatite, have sulphide ores been found. It is known that in Italian Somaliland, some miles to the east, both galena and cinnabar are present. As, in all probability, both these minerals have been obtained in an extension of the Black Slate formation, and as galena is present in British territory, there would appear to be a reasonable chance of cinnabar also being found in it. That mercury is known to the Somalis in the east is shown by the fact that they have their own name for it—biyu lagh (silver water). The writer, however, was unable at short notice to get a native who knew of any occurrence of it.

Moreover, it is to be noted that these two localities were found by Somalis quite by accident during the setting-up of huts. It is, therefore, more than likely that other deposits of the mineral exist in the Warsangeli district in the Black Slates, particularly as Unkah and Kul are situated about 13 miles apart.

As statements had been repeatedly made in Berbera that an old disused lead mine existed at Gedweda, between Hais and Las Gori, a search was made for the mine in the hills behind this place. The alleged mine proved to be a subterranean cave in Eocene limestone, of the same origin as similar caves in limestone elsewhere. Some vertical solution-channels of cylindrical form simulate small shafts. No galena or other lead ore, in fact no ore of any kind, was found in any part of the cave.

5. Salt.—

Salt has been produced for many years in brine pans or pools round Zeyla, and it has been found in a natural state in a hill one-and-a-half miles south of Hais, and, according to report, in Daga Der and Darraboh Hills, twenty-five miles east of Berbera and thirty-five miles north-east of Dagaha Shabell.

Formerly, there was a considerable trade in Zeyla salt inland to Abyssinia and overseas by export from Zeyla, but of late years this trade has fallen off very considerably and there is a danger of its ceasing altogether. The reasons for this are clear and may be set out briefly.

The industry has been all along in the hands of Somalis, Arabs or Indians, and the methods originally adopted many years ago have never been altered. When there was a good market for the salt no efforts were ever made to bring to its production up-to-date methods; no analysis of the product was obtained to ascertain the impurities present, the faults of the article, and the best means of getting rid of them and bringing the salt to the highest grade. It is true that a sample was sent to the Imperial Institute for analysis and report, but it was sent by the Administration and not by the holders of the concession, and only when the state of the industry had become seriously affected. The salt "pans," in places mere holes in the ground, are dirty, not enough care has been taken to ensure a bed free from impurities, or to ensure protection of the pans from surface drainage. No attempt has been made on the part of the owners or management of the concession to acquire a knowledge of the working of successful pans elsewhere, or if it was possessed, no effort has been made to apply it.

In short, from the very beginning, the management has been extremely inefficient, and its attitude has apparently been that, so long as sufficient of the product could be sold to give a profit without incurring any expenditure except for labour, only so long should the industry be carried on, and the article sold should only be that which has been produced from the beginning.

The result has been that, when salt pans formed by the French at Djibouti and properly chosen and arranged began to produce salt that was of superior quality, the demand for Zeyla salt immediately fell away and has now become very small. Doubtless the construction of the railway from Djibouti into Abyssinia has caused some of the loss of trade, but this amount is small in comparison with that brought about by the inferior quality of the product.

The writer, in the course of a journey from Djibouti to Zeyla and of his stay in Zeyla, was able to make a brief examination of the salt-pan area, and from this examination and from information obtained from the District Commissioner, it would appear that there is, under certain conditions, a reasonable prospect of the revival of the industry.

To begin with, the salt capable of being produced is of high quality. Samples of the crude material analysed at the Imperial Institute gave these results:—

	Per cent.	Commercial Table Salt.
$NaCl$	96·24	97·40
$MgCl_2$	0·45	0·08
$CaSO_4$	1·30	0·58
Moisture	1·28	0·15
Insoluble residue	0·75	1·71
Total ...	100·02	99·92

This analysis shows that even without purifying the salt compares very favourably with ordinary table salt.

By the simple method, moreover, of making a saturated solution, allowing the insoluble matter to settle and decanting off the clear brine into evaporation and crystallisation tanks, the material can be purified to give the following composition:—

		High Grade Table Salt.
$NaCl$	97·50	98·40
$MgCl_2$	0·45	0·28
$CaSO_4$	1·26	1·30
$MgSO_4$	—	—
Moisture	—	—
Insoluble residue	0·02	0·03

From this analysis it is clear that a salt can easily be obtained from the pans equal to any on the market.

Again, the area suitable for salt production is of considerable size. It extends from Warabod, about eight miles south of Zeyla, to El Ghori, about twenty miles west of Zeyla, and comprises the "pans" of Abdi Kalil, Surir, Dawanboth and Laheiloh.

Moreover, it is well-known that Somalis, accustomed always to the use of camels, prefer this form of transport to any other, and it is, therefore, probable that provided the article is equal to any sold, the competition of the railway as regards transport to the interior will not prove as successful as it is at present when only an inferior article is being carried from Zeyla.

Further, with a high grade article, and cheap transport facilities from Zeyla, there is no reason why the former overseas trade in salt from this port should not be revived. Some effort will, of course, be required, but efficient management of the industry should provide it.

To rehabilitate the industry, however, several conditions affecting the product must be observed. These include:—

(1) Efficient management. The manager should have not only business ability, but a knowledge of modern methods and requirements.

(2) Proper salt pans should be made to replace the crude native "pans" at present in use. Care should be taken that the bed of the pans should be clean and kept clean, and that surface drainage is prevented from flowing into the pans. There must be no direct communication of the pans with the sea except by canals, by which alone the sea water is introduced.

(3) Methods of producing salt from brine pans in places where the industry is a commercial success should be known or studied and, so far as practicable, be introduced.

(4) A cheap method of refining the crude salt, and not only of getting rid of the impurities but of producing the required grain, should be introduced. One has already been set out in a report by the Imperial Institute.

Though, up to the present, salt has been won from pans only round Zeyla, there appears to be a favourable outlook for its production in a similar manner immediately to the south and to the south-east of Karam, some 50 miles east of Berbera. South of this coastal police-post, there is the necessary flat, low-lying ground to which the sea-water could be easily admitted by canals, and which would form a clean bed that is unlikely to be contaminated by drainage. The only serious drawback to the locality may be that, owing to the sandy nature of the soil, there may be excessive loss of water before evaporation.

South-east of Karam, however, there are wide stretches of plain that would provide clean beds for the pans, with a firm soil through which percolation would be very slow, into which sea-water could be introduced without difficulty by canals, and which altogether appear very suitable. The salt, however, would have to be shipped only in small dhows from Karam, which is an open roadstead, or would require to be transported by camels to Berbera. Should it be found possible to exploit the coal south of Ankor, the same means of transport adopted for the latter could be used for the salt.

The salt deposit just south of Hais occurs in small caves just below the surface of the Eocene limestone cap on a small ridge which has been faulted down from the main limestone scarp further to the south. The mineral occurs in small lumps of a sugary appearance and consistency. An analysis of a sample at the Imperial Institute gave the following results:—

	Water-soluble constituents. per cent.
$NaCl$	81·49
$CaCl_2$	0·69
$MgCl_2$	0·35
$CaSO_4$	4·79
Total	97·32

The deposit is small, occurs sporadically, and can therefore only be of value for local use as a stock lick, for which purpose it is being employed at the present time.

The deposits at Dagah Der and Darraboh Hill are known only from the statement of Mr. H. M. O'Byrne, Collector of Customs at Berbera. Though the present writer had with him two native guides familiar with the whole district south of Karam, he was unable to find either of these two hills or any salt deposit in the district. This is explainable by the fact that hills throughout Somaliland, known to one section of a tribe by one name, are known to another section only by a totally different name, and by the probability that the salt specimens were collected for Mr. O'Byrne by Somali villagers. Had time permitted, an effort would have been made to discover the original collector of the specimens, as usually only by this means can deposits be found without considerable delay.

The notes accompanying the specimens were:—

1. "Pieces chipped from block in Dagah Der Hill through exposed orifice."
2. "Piece chipped from block in Darraboh Hill through exposed orifice."

Both samples were fragments of compact crystalline salt. Analyses of them made at the Imperial Institute gave:—

	Dagah Der. per cent.	Darraboh Hill. per cent.
$NaCl$	94·78	91·30
$NaHCO_3$	0·15	nil
$CaSO_4$	0·69	3·10
$CaCl_2$	0·47	0·24
Insoluble in water (chiefly $CaCO_3$)	4·05	4·61
Moisture	0·19	0·28
Total	100·33	99·53

Though the analyses show that the salt is fairly pure for naturally occurring material, in view of the fact that the mineral would have to be transported a considerable distance before purification, that, to judge from the notes, the deposits occur in caves and are probably of limited extent, and that very large quantities can be produced at a low cost at the sea-coast at Zeyla and probably at Karam, it is unlikely that either deposit would pay to work.

It has been alleged that the occurrence of these deposits may point to the possible presence of petroleum in the neighbourhood, but a geological examination of the country lying south of Karam as far as Las Dureh proves it to consist largely of eroded fault blocks of Dubar Sandstone capped in some instances by Eocene limestone, or, as at Ambal, of Jurassic limestone blocks capped by Dubar Sandstone, and, except for the pseudodome at Ambal, destitute of any structure that could act as an oil reservoir.

6. GUANO.—

A deposit of this material has for a long time been known to occur on Mait Island, a few miles off the coast near the police-post Hais. It had been, until the last few years, more or less regularly shipped over a long period by Somalis to the Sultan of Makulla to be used as a fertilizer for tobacco crops, but, owing to tribal disagreements and jealousy between Somalis and Arabs, work on the island was brought to a standstill. Except to a few native sub-tribes and a few Arabs, little is known of the deposit. No expert examination has ever been made of its extent and thickness, and the only specimens of it obtainable on the mainland are those collected by natives. An attempt was made by the writer to visit it, but, owing to the absence of a suitable dhow, either at Hais or at Humbais, and owing to the rough weather which lasted all the time he was in the neighbourhood of Hais and Mait, it was found impossible to get across in the time available. From Somalis, who had actually worked on the deposit, however, the following brief account of its nature was elicited.

The Island—which from the mainland appears quite white—is completely covered by the guano. The material occurs in two varieties: (*a*) the good stuff which forms the white layer that lies over the whole surface to a depth of two or three inches; (*b*) the inferior stuff which occurs in holes or cracks. The latter is the material collected when the Somalis work for anyone other than a white man or a Somali. Both varieties are of a brownish or buff colour. The deposit is scraped up without any regard to grade or impurities, with the result that, when bagged, it is mixed with numerous feathers, fragments of rock, bones and beaks, and ranges from an impalpable powder to pieces the size of screened road-metal. The stuff from a depth below two inches is not collected, and little is known at present as to what is the formation on which the deposit lies.

A typical sample of the guano in the condition in which it is bagged was obtained from the Customs House in Berbera, and was separated by sieving into the following portions:—

A. Feathers, bones, etc.
B. Portion retained on a sieve of $\frac{1}{8}$-inch mesh.
C. Portion passing an $\frac{1}{8}$-inch but retained on a $\frac{1}{20}$-inch mesh.
D. Portion passing a $\frac{1}{20}$-inch mesh.

Of a sample weighing about 20 lbs., the respective proportions under these divisions were:—

A. 0·8 per cent.
B. 25 per cent.
C. 17·5 per cent.
D. 56·7 per cent.

Portions B, C and D were then analysed and were found to contain the following amounts of phosphate, expressed as phosphoric anhydride (P_2O_5):—

B. 14·90 per cent.
C. 16·06 per cent.
D. 18·52 per cent.

The analyses show that the phosphate occurs throughout the whole sample. An examination of the material retained on the $\frac{1}{8}$-inch mesh indicates that the fragments in the fine powder included a small proportion of those of granite, of aplite, of flint, of black slate and of hornblendic gneiss. While, therefore, it would appear from the analyses that little advantage would be gained by rejecting any portion of the material of which the sample consisted, it is quite possible that the composition of the fragments varies considerably from place to place. In order to arrive at some conclusion as to the nature of the phosphate present, a few fragments were selected which were not obviously granitic or gneissic in character, and an analysis was made of them, with these results:—

P_2O_5	18·6
CaO	1·2
MgO	trace
Al_2O_3	5·4
Fe_2O_3	6·2
SiO_2	49·4

These figures show that only about 2·5 per cent. of calcium phosphate is present in the selected fragments, and that the greater part of the phosphoric acid occurs in combination with iron and aluminium, though it is obvious from the silica percentage that amongst the fragments was flint or the quartz probably of an igneous rock.

On the other hand, in connection with all the analyses, it must be borne in mind that until a proper examination is made of the deposit, and proper samples collected and analysed, it does not follow that they prove the true mineral character of the deposit. It is clear that some calcium phosphate is present, and it is quite possible that material from different parts of the island may contain different proportions of the calcium and of the iron and aluminium compound.

In view of the agricultural possibilities in the Protectorate and the proximity of the deposit to Hais, it is important that some reliable information should be obtained in regard to it. It is important to know its extent and thickness, whether pits occur in which the material is concentrated by water, what steps should be taken to improve the quality of the material bagged, what is the nature of the bed-rock, and whether any rock-phosphate occurs beneath the overlying deposit, part of which is scraped off. From examination of the fragments in the bag brought from Berbera, it is clear that, in part, the island is composed of slate and gneiss with intrusive granite, but it is not known whether these rocks form the whole of the island or outcrop only in some places beneath the limestone cap. Even should it be found that most of the phosphate is an iron or aluminium compound, undoubtedly its quality can be considerably improved by sieving or screening before bagging. Moreover, though the presence of iron oxide and alumina is an objectionable feature in the manufacture of superphosphate when the amount reaches 10 per cent., there is no reason why the guano cannot be used as a manure without conversion to superphosphate. It has in fact been used on Makulla. The phosphate in its natural state is in a form in which it is largely available for plant nutrition, and even if it could not be used for the manufacture of "soluble guano," it could be used in its natural state as a fertiliser, after the simple process of fine grinding.

The island is still year by year the haunt of countless birds and the deposit is thus being annually increased.

It is of interest to note that some similar deposits have already been reported and described from the Aldabra group of islands in the Seychelles.* On Assumption Island, the phosphate is chiefly phosphate of lime—though some iron and aluminium phosphate is also present—but on other islands of the group the amount of iron oxide and alumina amounts to 8 or 10 per cent., and it is held by Mr. Dupont† that even when this amount is present, the material could be used either for the manufacture of "soluble guano" or as a soil fertiliser after fine grinding. In the Seychelles, the pits contain material of richer quality than the surface guano, and it would certainly appear that the statements of the Somalis to the effect that the guano in holes and cracks on Mait Island is of inferior quality, are erroneous.

7. Mica.—

Samples of muscovite mica were sent from the Protectorate to the Imperial Institute for report as long ago as 1901, and these samples were submitted to firms of mica brokers for an estimate of their value. Though they were apparently rather small both as regards quantity and size, the brokers considered that they gave promise of good mica being found in the deposits, and that, in view of the cheapness of labour and freight, the deposits might pay to work.

As the uses to which mica is put and the consequent demand for it have increased very considerably since 1901, special attention was paid by the writer to the occurrence of the mineral within reasonable distance of the coast.

Muscovite mica, and, in places, pale biotite, proved to be very common in a large area of country comprising the foothills and northern and north-western slopes of the Mirsa plateau, about 40 miles south of Berbera, and also in the hills at the base of the Golis Range as far west as Mandera. The rocks of all this country are chiefly granitic and hornblendic gneisses intruded by granite-pegmatite dykes, some flesh-red, others white, others again pink-and-white owing to the presence of both pink and white microcline. Mica is most common in the pink-and-white, less common in the white, and rare in the flesh-red dykes. Everywhere on the track over the plateau from Mandera to Darass, books of the mineral are to be found of a size about two inches by two inches, and, at several spots, comparatively large deposits containing books up to four inches by four inches were met with. At Durriehauseh, for instance, on the west side of the plateau, there is a large dyke traceable for a length of 300 yards, and 30 feet in thickness, in which numerous large books of a pale biotite occur all over the surface, and a hole sunk at one spot for a depth of about three feet showed a solid mass of books of the mineral of an average size of four inches by four inches. Other dykes

* Bull. Imper. Instit. Vol. IX., 1911, p. 39.
† The writer of the article referred to.

of similar appearance were seen in the neighbourhood and there is a good prospect that other large deposits could be found by sinking or by blasting. The mica from this locality was of a pale brown tint, but, having been got from near the surface, was more or less weathered, cracked and discoloured. Owing to lack of time and the necessary implements and labour, it was not possible to open out the deposit, but sufficient evidence existed in the hole sunk to show that the quality improves as the depth below the surface increases.

The smaller books from the track are of a pale green or amethyst tint and quite free from flaws.

The best indications, however, of the occurrence of good mica—muscovite—were obtained in the foothills of the plateau, in the area lying between Hul Kaboba and Lafarug. A sample of excellent muscovite sent to the Imperial Institute in 1901, measuring over four inches by four inches and free from flaws was got from this area, and an inspection made by the writer of the vicinity of Humbeleh, near Lafarug, showed large quantities of the mineral forming small mounds at the base of the hills. Enough work could be done with a pick and a spade to prove that many of the mounds consisted very largely of mica books, and though the surface specimens exhibited cracks and hydration strains, it was clear that the quality of the mineral improved to a great extent with depth below the surface. Many of the books virtually free from serious flaws measured up to six inches by six inches, and it is very probable that, by the use of proper tools and blasting powder, considerable workable deposits of good quality could be opened up. The area is one which should be thoroughly prospected, and each mica occurrence should be opened up to a sufficient extent to enable thoroughly representative samples to be obtained for expert valuation both of the mineral and of the deposit, particularly as the area is within easy distance of Berbera, and transport to and from it presents no difficulties.

As it has been repeatedly asserted, on the strength of Somali reports, that good mica, together with carnelians and precious stones, occurred in Yubaleh Range in the Gadabursi district, an examination was made of this range. The rocks of which it is composed are similar to those of the Mirsa plateau, there are the same varieties of granite-pegmatite dykes, and a considerable amount of muscovite mica is present in the dykes. Not only, however, did the size of the books nowhere exceed two inches by two inches, but no considerable deposit composed of books even of this size was encountered. The alleged carnelians proved to be flesh-red microcline felspar or rounded pebbles of flesh-red quartz, and, in spite of a careful search, no precious stones were discovered. Brown garnet, however, is plentiful in the pegmatites, and it is most probable that this mineral was mistaken for a gemstone.

Muscovite mica was also met with in Sigip Range, which is similar in composition to Yubaleh Range. So far as could be seen, the size of the books and the quantity of mica in the dykes were no greater than in Yubaleh. In any case, even if muscovite mica of marketable size and quality were to be found in either of these ranges, it would not pay to work at present on account of their distance from the nearest port (Zeyla), and the cost of transport.

It is asserted by Somalis that very good mica exists in the unexplored area north of Hargeisa, and, as the assertions are made by men who have seen material that is really of value, some reliance must be placed in them. Owing to the necessity of using the favourable season for an examination of the Warsangeli District, it was not possible to traverse this area.

It may be of benefit to give here some details obtained on request through the Imperial Institute from various mica brokers as to their requirements and the present price of the mineral.

There is no open mica market in the United Kingdom and current prices are not quoted, owing to the large number of grades and sizes marketed and the rapid fluctuations in supply and demand for some of them. Properly graded lots sent to a reliable broker will realise their current market value, less a small commission for selling.

It is of the utmost importance that mica sent to this* country for sale should be properly trimmed, sorted, graded and packed. If a broker can be sure that each parcel of a particular producer's consignment will contain material of only one size and grade, properly trimmed and packed, that producer is assured of a much higher price for his mica, as, in other cases, the material has to be re-sorted on reaching the broker's hands.

There is at present a good demand in London for sizes 2 inches by 1 inch and 2 inches by 2 inches if the quality is satisfactory, though they are not always so easy to dispose of. The smallest sizes are commonly used in the manufacture of "micanite," for which thin splittings from $\frac{1}{500}$ inch to $\frac{1}{1000}$ inch are required.

* England.

As regards current values, it may be stated that consignments of mica have, in 1924, realised the following prices:—

Clear good, No. 1 size	25s. per lb.
Clear good, No. 3 size	17s. per lb.
Slight stained, No. 1 size	16s. per lb.
Slight stained, No. 3 size	10s. 6d. per lb.
Splittings:—	
No. 6 size, good quality, loose	5d. per lb.
No. 5 size, good quality, pan packed	1s. 3d. per lb.
No. 5 size, best quality, pan packed	3s. 9d. per lb.

8. Beryl.—

Associated with the mica in the large pegmatite at Durriehauseh, already referred to, large crystals of pale green beryl were found, some of them measuring a foot long and about six inches across, and all with more or less regular prismatic form. The mineral appeared to be distributed throughout the dyke, and even in a space of about five yards square six large crystals were counted. Moreover, that there are other beryl-bearing dykes in the vicinity is proved by the fact that, in tugs flowing northwards from the foothills somewhat to the east of Durriehauseh, crystals and small crystal fragments of the mineral were found. As beryl is at present of some commercial value—according to information in possession of the Imperial Institute, an offer of £10 per ton has been made for it by one firm—and, seeing that, if the experiments which are now being made to replace aluminium by the lighter beryllium in the manufacture of aeroplanes prove successful, it will be of greater commercial value, the area in which it has been found should be thoroughly prospected for further occurrences, a sufficient quantity should be sent to London as a trial sample, and steps should be taken to obtain a reasonably accurate estimate of the amount of the mineral that can be got from the area.

The crystals are both too large and of too pale a tint to be of much value in themselves as gemstones. As it is, however, not unusual to find that where beryl-bearing pegmatites intrude greenstones, the beryl acquires a deeper shade of green at the contact and may then prove a marketable gemstone, the contacts of these dykes with either the hornblende gneiss or the talc-chlorite rocks of the plateau should be carefully examined.

9. Garnet.—

Crystals of brownish and reddish-brown garnet are very common in the granite-pegmatites that intrude the granitic gneisses of the Protectorate, and small crystals of red garnet occur in considerable number in the hornblende gneiss of Darinwadu tug near Buk Gigo, south-east of Zeyla. In general, the mineral is not present in sufficient quantity and occurs too far from a port to be worth consideration.

In the mica pegmatites of the Mirsa Plateau, however, and particularly in those in the neighbourhood of Humbeleh near Lafarug, the mineral was found in quantity sufficient to suggest that there may be amounts large enough to exploit. In one dyke, lumps of a dark reddish-brown garnet weighing several pounds were obtained. A sample of it, much weathered and iron-stained, was submitted to a firm of abrasive importers and manufacturers, who stated that, while it was too much weathered and decomposed to be in itself of any commercial value, there was a considerable probability that marketable material might be met with below the surface. The firm were of opinion that a further survey of the deposits was desirable, and were prepared, if better material were found, to make practical trials and arrange for its sale and distribution.

The fact that the mica, beryl and garnet all occur in the same neighbourhood and are capable of being worked together will react favourably on the chances of exploiting these occurrences.

10. Barite.—

Barite was found in two places in Bihendula Range: (1) In a small tug on the north-east margin of the gneissic mass just below the sandstone, which forms the base of a small outcrop of Jurassic limestone in contact with Daban conglomerates. (2) On the motor road from Berbera to the Bihendula rest-house, in a gorge below the hill called Ardah about two miles north-west of the rest-house, and one-eighth of a mile to the south-east of the track.

(1) In the small tug on the north-east margin of the gneiss, the mineral occurs in foliated hornblende gneiss, along joint planes, cracks, or what are perhaps slip zones, in veins from $1\frac{1}{2}$ inches to $1\frac{1}{2}$ feet in thickness. The foliation of the gneiss strikes N. 18° W., and pink and white felspar pegmatite veins and dykes run parallel with this foliation. The similarity between some of these pegmatite veins and those of the barite may lead to the occurrence of the latter being missed unless the high specific gravity of the barite is kept in mind. The veins of the mineral, in contrast with the pegmatite, run in a direction W. 10° N.-E. 10° S., and the slip planes along which

the mineral occurs appear to dip 60° in a north-westerly direction. There appears to be plenty of barite in the locality, floaters being found all along the tug, but, as the veins disappear under the gritty Jurassic sandstone, it was not possible to ascertain how far they extend along the strike.

(2) In the gorge below Ardah, occurs a large vein of barite, composed in places of three bands each nine inches thick, but mostly of one band about two feet thick. The vein can be traced for 200 yards up the hill in a south-easterly direction from the gorge, and for 100 yards in a north-westerly direction towards the motor track. There are a fair number of floaters on the camel track and in the gorge and the tug. The mineral occurs in a gray granitic or slightly hornblendic gneiss in which are numerous joint planes at right angles to the foliation of the gneiss, the strike of which is N. 36° E., or virtually north-east—south-west. The trend of the vein, on the other hand, is N. 40° W., or virtually north-west—south-east.

The barite fills a crack or fissure or joint-plane in the gneiss. Though a small fault has bent the course of the vein at one point, there does not appear to have been any considerable faulting in the neighbourhood, and it is improbable that the crack or fissure marks a fault-plane. On the other hand, as the joint planes in the gneiss run in a direction N. 40° W., *i.e.*, that in which the vein itself runs, it is most probable that the mineral occupies a joint plane.

The barite is white, in places with a slight pinkish tint, and appears to be very pure. An analysis of a typical specimen made at the Imperial Institute gave these results:—

	Per cent.
BaO	60·77
SrO	2·43
CaO	1·41
SiO_2	1·50
$Fe\ O$	0·26
MgO	0·17
SO_3	33·76
Total	100·30

According to the report accompanying the details of the analysis, the sample was of good white colour when finely ground, and material of similar quality would probably be suitable for purposes to which ground barite is generally applied.

The sample was, of course, only a surface one, and it is possible that the amount of lime contained in it may be smaller in material from greater depths.

There is little doubt that other veins of the mineral occur in this range and could be found with little trouble.

II. Celestite.—

This mineral was first recognised by the writer in Ferrio Range, about a mile west of Gabile Well, in a small outcrop of yellow shales forming part of the Gypsum Series that overlies the Eocene limestone, and forming the bank of a small tug. Subsequently, it was found in greater or less amount in every ridge on which the Gypsum Series was present, and there is no doubt that it occurs everywhere in these yellow shales. Near Gabile, the celestite is in small masses of translucent white crystals which have hitherto probably been mistaken for gypsum.

The chief deposit met with, however, was on the west side of the saddle between Himbir Yer and Himbir Wein tugs, on the main track from Hebah Las to Gerfoleh in Ferrio Range. The mineral there formed an outcrop on the surface, of several square yards in extent but of unknown depth, composed of crystals of size up to three inches square. There must be many other similar masses to be found both in this range and in the Gypsum Series on Al Wein Range.

An analysis of samples from near Gabile and from the saddle near Himbir Wein made at the Imperial Institute gave the following proportions:—

	Gabile. Per cent.	Himbir Wein. Per cent.
SrO	55·30	54·94
BaO	nil	nil
CaO	0·46	0·52
SiO_2	0·25	0·97
Fe_2O_3	0·26	0·10
MgO	0·20	0·26
SO_3	43·52	42·72
Total ...	99·99	99·51

According to the report accompanying the results, the samples were of good white colour when finely ground, and material of similar quality would probably be suitable for the purposes to which ground celestite is generally applied, though it is doubtful whether supplies of the mineral from Somaliland could be profitably disposed of on the English market in competition with the material obtained in the United Kingdom.

In parts of Ferrio Range, occasional crystals of a blue, somewhat fibrous variety of the mineral are met with, and in the banks of Dudub tug, between Las Dureh and Hodmo tug, large round aggregates of circular crystals occur in the Eocene limestone.

12. Molybdenite.—

This mineral was found in rocks in Dobo Tug about a quarter of a mile up the tug from Dobo Well, near Wobleh Range in the Gadabursi country. Wobleh Range itself consists of coarse and fine-grained granitic gneiss with dykes of pink, of white, and of pink-and-white granite pegmatite. The molybdenite occurs in splashes and nests in the pink-and-white pegmatite. Only one dyke containing the mineral was encountered, and only a small amount of the mineral was found in it, but as, owing to considerations of time and the roughness of the country, it was not possible to examine more than a few pegmatites, a further search of the neighbourhood would probably result in the discovery of other occurrences. A considerable improvement, however, on the present state of the communications between Dobo and either Zeyla or Hargeisa would be necessary before any deposit could be exploited.

13. Gypsum (Massive, Selenite and Satin-Spar).—

Gypsum deposits of very large extent and thickness have been found in different parts of the Protectorate, particularly in the Guban, on the eastern portion of the high plateau, and in the south-eastern district from Kirrit eastwards. The chief localities are: the southern slopes of Al Wein Range, about sixteen miles south-east of Berbera; the southern slopes of Ferrio Range, about ten miles south-east of Al Wein Range; the neighbourhood of Las Dureh, Dodab and Las Adey; the hills and tugs in the east of the plateau from Dabbar Dalol and El Afweina to Erigavo and Jid Ali, and probably as far as the eastern boundary; between Biji and Bia Bolgashan on the Kabal-Kabat track, north-east of Hargeisa and south of Bulhar.

The mineral occurs in three forms:—

1. Massive gypsum, associated with anhydrite.
2. Selenite and Satin-Spar.
3. Alabaster.

1. Almost the whole of the gypsum in the Protectorate occurs in the massive form, but the two chief deposits are those forming the uppermost beds of Al Wein Range and Ferrio Range. The gypsum of Al Wein, which covers all the southern slopes, is probably quite 2,000 feet thick, and dips conformably with the Eocene limestones underlying it. The slopes are deeply intersected by ravines, the sides and floor of which are all formed of the mineral. The gypsum is commonly of a greyish or yellowish-grey hue. In places, however, are white streaks, patches and small blocks surrounded by the greyish material, and on the floor of some of the tugs in Al Wein, a more or less gradual passage of the white into the grey mineral can be traced. Analysis at the Imperial Institute of a sample of the white mineral from Agagwein Ridge gave the following results:—

	per cent.
$CaSO_4$	90·30
$CaCO_3$	1·68
$Ca(NO_3)_2$	0·17
KCl	0·89
$NaCl$	2·01
$Fe_2O_3+Al_2O_3$	0·17
MgO	0·58
SiO_2	0·32
H_2O	4·51
Total	100·63

Calculation, from this analysis, of the amount of gypsum ($CaSO_4.2H_2O$) present shows that, assuming all the H_2O to be present in gypsum, only 21·5 per cent. of gypsum is present in the sample. The remainder of the $CaSO_4$, amounting to 73·3 per cent., is, therefore, in all probability present as anhydrite. Results of specific gravity tests on specimens composed of both the white and grey material, and evidence of a gradual passage of the white mineral into the grey strongly support this conclusion. Indeed, it is most likely that all the gypsum was originally in the form of anhydrite, but has been transformed by exposure to air and moisture.

The gypsum of Ferrio Range occurs in exactly the same manner and is of approximately the same thickness as that at Al Wein. In the neighbourhood of Las Dureh, Dodab and Las Adey, it forms the surface of the fairly level ground, but is seamed by ravines, many of which are fifty feet deep with walls and floor wholly of the mineral.

2. Selenite and Satin-Spar.—Selenite occurs as thin bands in the massive gypsum, in great amount in the shales and sandy shales of the Daban Series near Khal Der, and, in a state of great purity, in the massive gypsum walls of Dodab tug. Nowhere, however, were any large homogeneous deposits of it encountered, though many tons of it could be collected from Khal Der, where it occurs in plates about a foot square and up to an inch thick on the surface of the shale outcrops.

Satin-Spar, or fibrous gypsum, occurs in the same manner as selenite as veins up to a foot in thickness in all the outcrops of massive gypsum, and veins of this variety are especially common on Al Wein, and in Dodab tug.

Both varieties are common in very thin plates in the clay shales of the Upper Eocene, and even in the kerogenous shales of the Jurassic at Meragelleh.

3. Alabaster.—Large deposits of this variety, exceeding twenty feet in thickness, were met with at Dabbar Dalol Well, about seven miles south of El Afweina, in the east of the Protectorate. The material occurs in slabs measuring from one foot to two feet square and from three inches to six inches thick. It is fairly pure, and of a dead-white colour on the exposed surface and when rubbed.

Another deposit at least twenty feet thick and extending along a tug for at least half-a-mile occurs at Dodab. The mineral is greyish-white in colour and shows a more or less distinct veining.

The prospects of the deposits from an industrial standpoint are, for the present, at any rate, scarcely worth considering. Except in the case of the deposit on Al Wein, the cost of transport of the material to a port or even to any place where a factory could be established, would, in view of the low market value of the material, effectually prevent it being worked successfully, and it is fairly certain that, though the Al Wein deposit is sufficiently near Berbera to present no difficulties as regards transport, it would not be profitable to export gypsum from it to European or other overseas markets.

Should, however, agriculture be seriously attempted in the Protectorate, the finely-ground pure material may be of use locally as a fertiliser.

14. Gold.—

In Vol. XVI of the Peace Handbooks,* the question of the occurrence of gold in British Somaliland is dealt with in these terms:—

"Statements are to be met with, especially in older accounts of the country, to the effect that goldfields exist in British Somaliland.

"It has been suggested that the gold-producing district, known to the ancient Ethiopian Empire as Sasu, may be located in the north-east corner of Somaliland, stretching southwards in the direction of Obbia in Italian Somaliland. Attempts have also been made to prove that the gold-bearing country known to the ancient Egyptians as Punt is identical with these parts of Somaliland. There is, however, no evidence of the existence of goldfields in the country. The ranges of the Somali hinterland are Archæan gneisses, schists and granites, but, notwithstanding their resemblance to Egypt, they do not, so far as is known, furnish auriferous deposits."

In the Military Report on Somaliland, and in the Military Handbook on Abyssinia, the statement is made that both alluvial gold and gold in quartz occur in the Protectorate, and, on an official file in Berbera, is a statement that a sample of gold in quartz obtained in Somaliland was taken to Delagoa Bay in 1903. No mention, however, is made of the locality from which these specimens are alleged to have been obtained, nor is there any official record of their discovery.

Particular attention was paid by the writer to the possibility of finding this mineral, and, though no gold was found *in situ* or in the gravels and sands collected, two districts were met with in which, from the nature of the rocks and the character of the quartz, its occurrence might be expected. These were:—

1. The slate country south-east of Las Gori, in the Warsangeli district, in the north-east of the Protectorate.

2. The country a little west of Boramo and in the vicinity of Halissa and Debraweina.

* 1920, No. 97, p. 32.

1. The series of slates is seamed with veins and reefs of quartz, many of them several feet thick. The quartz is usually ferruginous with a cellular or porous structure due to the decomposition, probably, of iron pyrites, and, therefore, of a character which, in the light of experience elsewhere, must be regarded as favourable for the occurrence of gold. Time did not allow of the sampling of more than a very few of the veins and of the stream sands, and, though no gold was found in those examined nor was any visible gold met with in the veins and reefs, yet, in view of the great extent of the slate country, the great number of quartz reefs, and the fact that even in a proved gold-bearing country, gold does not occur in all the reefs, there is some prospect of the discovery of the mineral in this district, and it warrants careful prospecting. That these black slates are the rocks in which galena also is found in British territory and probably galena and cinnabar in Italian territory renders the district all the more worthy of special attention.

An assay of a sample obtained from a quartz reef near the galena occurrence at Unkah, but showing no galena whatever, gave:—

Gold	trace.
Silver	1 dwt. 9 grs. per ton.

From this result it would seem that though the sample was of no value in itself, yet the reef is to some extent argentiferous and may be auriferous.

In view of the presence of the numerous ferruginous reefs and veins, a special interest, therefore, attaches to past attempts to reconcile this north-eastern part of the Protectorate with the Sasu region of the Ethiopian Empire. The Somalis themselves are firmly of opinion that gold has been obtained in it, though the justification for their opinion could not be elicited.

2. The country near Boramo and in the vicinity of Debraweina appears also to be worth prospecting. On the trek from Somadu to Boramo, the writer was impressed with the possibility of the occurrence of gold in the district south of Dorjibis, which is only a few miles north and north-east of Debraweina.

A sample taken from a small tug at Dorjibis, assayed at the Imperial Institute, gave:—

Gold	trace.
Silver	12 grains per ton.

Another sample, of sand, taken from the bank of Amud Tug, east of Boramo, gave:—

Gold	trace.
Silver	1 dwt. 1 grain per ton.

In the report on the results of the assays, the Institute remarks that most of them are of interest as indicating the presence of gold in the localities from which they were obtained.

Moreover, about a fortnight before the writer left the Protectorate, he accidentally came across amongst the official files an old volume in which was a letter from a Colonel Ashby, containing the statement that he had found gold in 1900 (or 1901) in the Debraweina district, and that he had had numerous coolies working on the occurrence. Apparently, as was the case in other connections, the unrest arising from the operations of the Mad Mullah caused the abandonment of the work. It is clear, however, that he must have discovered some valuable mineral in promising quantity, for otherwise he would scarcely have had a large number of coolies at work on the occurrence. It is regrettable that no access could be had to this letter in time to allow of an examination of the locality. At the time of its discovery, the period of the tour had ended.

In the light, then, of the statements in the letter, and of the finding of apparently favourable country a few miles to the north of Debraweina, there can be no doubt that the prospects of the tract outlined are sufficient to warrant a careful and intelligent search of it for precious metals.

15. Clay.—

Owing to native rumours of the occurrence of soapstone near Bayal Well, north of Bihendula Range, a Somali who knew the occurrence was sent by the writer to collect specimens of it for examination. The material brought in consisted of fragments and round lumps of a pale grey and of a pale green colour, which, both in appearance, hardness and feel, closely resembled soapstone. Blowpipe examination, however, showed it to be not soapstone but an aluminium silicate. Subsequent reference to the records of the Imperial Institute showed that samples of this substance had been analysed in 1920, with the following results:—

	Per cent.
SiO_2	49·92
Al_2O_3	15·35
Fe_2O_3	2·49
TiO_2	0·36
CaO	1·40
MgO	5·86
Na_2O	1·30
K_2O	trace
Loss on ignition	22·42
Total	99·10

These results indicate that the composition of the clay is nearly the same as that of montmorillonite. Tests carried out at the Institute show that it would not be suitable for the manufacture of pottery or bricks, as any article made from it cracks badly on drying. Its particular importance lies in the fact that, when ground, it is a clay which, according to the Imperial Institute, could be used satisfactorily as a clarifier in oil refining, and, having regard to the possibilities of the petroleum seepage at Dagaha Shabell, the occurrence, therefore, merits being placed on record. The material forms part of two small hills near Bayal Well, about twenty miles south-east of Berbera.

Up to the present, no clays of commercial value other than the above have been found. Yellowish clays do occur as bands in the Jurassic limestone and some whitish clay-shales were met with in the Abassa Tug near Abassa Dadera, but, even if they were of value in themselves as an ingredient of cement, the general inaccessibility of the localities in which they occur would render them of little practical importance. It is possible, however, that there are clays interbedded with the Eocene and Coastal limestones which could be used profitably in the manufacture of cement and attention should continue to be directed to their discovery.

16. Talc (Soapstone).—

Thin veins of this mineral were found on the surface on the track from Darass to Dumoyera, about two miles east of Darass, on the Mirsa Plateau. The veins are obscured by scrub and grass, and their thickness could not be accurately determined. In this particular locality, however, it did not appear to exceed two or three inches. Nevertheless, on a small hill on the left of the track from Darass to Sheikh, there are large blocks of a greenish talc-chlorite rock. Considerable masses of this rock occur *in situ* in and around the hill, and as the veins of talc in all probability occur in it on the track, there is, therefore, a prospect of other veins or masses of talc being found elsewhere in the locality. The rock itself is used by Tomals as a furnace bed or natural forge in the manufacture of spears and crude tools.

17. Marble.—

On the track from Burao north-eastwards towards Ok Pass and about fifteen miles south-east of the Pass on the west of the track, are several small hills to which the name Demirjogh has been given. These hills are isolated, of a pale yellow or buff colour, and at first sight appear to be formed largely of felsitic quartz porphyry. Closer examination shows them to consist in part of hornblende gneiss, in part of granitic gneiss with small dykes of coarse granite, but in large part of the pale yellow rock. The latter, on being broken, proves to be not an igneous rock at all, but a white crystalline limestone or marble of medium texture. The marble occurs in parallel bands, and in one hill there are as many as fifteen parallel bands from one foot to four feet wide. The strike of the bands in this hill is N. 15° E. and the dip is vertical. In one hill about a mile further to the north-east, the strike veers round from N. 15° E. to N. 40° E. and the dip is 60° to the north-west. In a third hill about three-quarters of a mile to the north-east, the strike veers round in a curve from N. 15° E. to N. 65° E., the change being due to the influence of intrusive granite-pegmatite dykes.

In the first hill, the marble is associated closely with black hornblende gneiss, which occurs not only in juxtaposition to the limestone mass, but as lenticles, xenoliths and dyke-like veins in it, and occurs also between the bands with the same strike as the marble. The lenticles are in places coarse epidiorite, in places almost a hornblendite, and in places appear as pale grey knots in the limestone.

The marble exhibits peculiar parallel lamination brought out by weathering, and in places the lines or edges of the laminæ are curved to form three parts of a circle, apparently owing to the intrusion of a hornblende gneiss or a granite dyke. In the hill three-quarters of a mile to the north-east of the first, a granite-pegmatite also forms knots in the marble, but no contact minerals were found.

The comparative ages and relation to one another and to the surrounding country of the marble and the hornblende gneiss are important and complicated and are referred to elsewhere. Apparently the limestone represents a very old sedimentary series that has not hitherto been recognised in the Protectorate.

Some of the hillocks are 150 feet wide, 600 feet long in the direction of the strike, and rise to forty feet above the level of the plain.

The marble is white on the fresh surface, slightly dolomitic, fairly hard, crystalline, and very tough, but probably of rather too coarse a texture for use as statuary marble. It may, however, in the future be of some local value as a building and ornamental stone. At the present time there is not, except possibly at Burao, sufficient need, in the Protectorate, of good building stone to compensate for the difficulty of transporting this marble.

A similar marble was met with on the track just north-west of Dorjibis, between Somadu and Boramo in Western Somaliland. There it occurred as a band in a series of foliated quartz-mica schists. As the band, however, nowhere exceeded one foot in thickness, it could be of no other than scientific interest.

18. MANGANESE ORE.—

In 1917, a sample of calcareous wad sent from Berbera was reported on by the Imperial Institute. The report stated that the material contained 8·55 per cent. of manganese and that it should be ascertained how the deposit originated, since it might be traceable to beds of manganese ore of economic value. The locality given in the letter accompanying the sample was "from Jirba Hill, about 30 miles eastwards from Ali Wein."

As Jirba Hill is a ridge over six miles long and two miles wide, it was a matter of some difficulty to locate the deposit, but it was eventually found in Bihen Gaha Pass, at the north end of the ridge, close to the easternmost of the three hot springs which issue from the Eocene limestone in the Pass.

The deposit forms a patch about 20 yards square, and the manganese is in the form of a black powder, intermixed with calcareous limestone, some salt, and finely divided carbonaceous material. The actual amount of manganese ore in the deposit is small, some of the travertine containing none of it, and, to judge from the evidence in a hole sunk in it, the deposit is patchy and extends downwards for only a few feet. To open out the deposit properly, however, blasting powder and more labour and tools than the writer was provided with would be necessary.

Samples of the black travertine from the side of the hot spring were analysed at the Imperial Institute, and the results obtained are as follows:—

	Per cent.
MnO_2	11·09*
MnO	1·84*
$Fe_2O_3 + Al_2O_3$	0·47
CaO	44·84
MgO	1·55
SiO_2	0·72

These figures closely approximate to those obtained from the sample analysed in 1917, and indicate that the ore is of such low grade as to be of no commercial value. Nevertheless, because of the possibility of the existence of a deposit of psilomelane or of pyrolusite in the vicinity of, but not in contact with the springs, from which this wad might have been produced, a search of the surrounding hills was made. No deposit of manganese ore of appreciable size was discovered anywhere in the neighbourhood, but in a ridge of massive Eocene limestone just north of the spring, small veins of calcium carbonate with streaks of manganese oxide through them, and cracks and joint-planes with a crust of dead-black manganese oxide intermixed with calcium carbonate were found. It would appear, therefore, that either this limestone originally contained a certain amount of manganese oxide probably as a sea-bottom deposit, or that beds formerly overlying the limestone contained a small amount of the ore; that in the former case, the manganese has become leached away and re-deposited in the cracks and joint planes along with secondary carbonate of lime; that, in the latter, the manganese oxide percolated in solution down through the cracks and joint planes and was re-deposited in a similar manner; and that, finally, this re-deposited oxide has again been leached out, and, coming in contact either with organic matter round the hot spring or with the mineralised water of the spring, has again been thrown out of solution in the calcareous wad.

In any case, so far as is shown by the evidence at present available, the deposit is of no commercial value and no other deposits of the mineral worthy of any attention occur in the vicinity.

* Together equivalent to 8·42 per cent. of metallic manganese.

19. Kerogenous Shales.—

As already stated in the section dealing with Petroleum, kerogenous shales were found in several localities in the country examined. Samples of them were collected from each locality and three of them have been analysed at the Imperial Institute, viz.:—

(1) That from the bed of the Durdur Ad tug near Meragelleh, in the Gadabursi District.

(2) That from the same tug but from a different spot in the bed.

(3) That from a gorge west-north-west of Bihen Gaha springs, south of Karam.

The results obtained on distillation were:—

	No. 1.	No. 2.	No. 3.
Crude oil, gallons per ton	10·3	6·6	1·1
Ammonium sulphate, lbs. per ton	28·3	33·0	17·7

The oil produced was dark-brown and limpid, and had the characteristic smell of shale oil. Considerable quantities of sulphuretted hydrogen were evolved during the distillation.

The yields of oil from these three specimens are low and the quantities of ammonium sulphate obtained are smaller than those obtained from low-grade Scottish oil-shales. It would not be remunerative to exploit material of the quality represented by these specimens.

On the other hand, the analyses prove conclusively that the black and brown shales underlying the Jurassic limestone in various parts of the Protectorate are kerogenous. Moreover, the samples obtained were merely surface samples that had been exposed to the atmosphere for long periods, and it is possible that fresher material from some distance below the surface would give a larger return of oil. In view, however, of the inaccessibility of the best of the shales—those at Meragelleh—it is unlikely that they would ever pay to exploit.

20. Graphite.—

Graphite was found as a constituent of a fine-grained, friable, very quartzose gneiss on the right bank of Ulauleh tug, half-way up the tug on the track from Durrieodera and Elaudu, in the south-west of the Gadabursi District. The mineral occurs in the rock in considerable amount as fine flakes, but the extent to which the rock itself occurs could not be determined on account of undergrowth and débris. Though no workable deposit was seen, the discovery of the mineral is of interest, because it indicates a mode of occurrence similar to that in other African Protectorates.

21. Diamonds.—

Assertions have been made by a South African syndicate that diamonds occur and have been found in the south-east of the Protectorate, and an application was made by it for permission to prospect for them in the neighbourhood of Kirrit. This part of the country, being at least 150 miles south of Berbera, was, of course, outside the limits for the time being prescribed for investigation by the writer, but at the request of the Governor, a visit was paid to Kirrit to determine whether there was any promise of diamonds being found there. The neighbourhood of Kirrit consists of Eocene limestone ridges—such as Dur Dab, and gysum hills—such as Kirrit Hill itself—which in the coastal regions belong to a series overlying the Eocene limestone. Though the whole area within a radius of five miles from Kirrit Hill was examined, no diamondiferous rocks or sands were found in it, and, having regard to the lithological character of this area, there does not appear to be the slightest chance of diamonds being found naturally in it. It is, of course, not known on what gounds the assertions of the syndicate have been based, but whatever blue clay exists—and none comparable to the Kimberley blue clay was found by the writer—cannot, in this neighbourhood, be of other than a sedimentary origin, and of the Eocene or post-Eocene stratigraphical series.

On the other hand, it by no means follows that, because Kirrit was given by the syndicate as a base or starting-point, the diamonds alleged to have been found or expected to be found necessarily came or would come from Kirrit itself or even from its immediate vicinity. Indeed, it is most unlikely that the actual locality at which they may occur would be divulged, and most probable that it would be at a considerable distance from this spot, though not so far as would prevent it from being used as a convenient base on the motor road from Burao.

The country to the south, west and east of Kirrit has not been geologically examined, and though the surroundings of Kirrit itself are formed of limestone and gypsum, the common occurrence in Somali nomenclature in the district of the words "madu," "madoba" (meaning "black"), applied to hills rather suggests that the rocks of the district are not all limestone and gypsum, but that some of them may be of extrusive or intrusive origin. It would appear, therefore, that either an expert examination of

the whole district should be made, or that the activities of the syndicate and the results achieved should be kept under expert observation and duly recorded in the interests of the Administration.

22. SANDS.—

In all, forty-four samples of sand were collected from various tugs, examined roughly on the spot by the aid of a magnifying glass, and then concentrated by panning where water was available, by passing them through a 20-mesh sieve where no water could be obtained. These sands have been further investigated at the Imperial Institute in part by electromagnetic separation, in part by further careful panning. No valuable minerals, however, have been discovered in them.* They consist almost wholly of hornblende, magnetite, ilmenite, felspar and quartz on the one hand, and of mica, garnet, zircon, ilmenite, magnetite, quartz, felspar on the other, *i.e.*, they are sands derived in the one case from hornblende schists and gneisses, on the other from granite gneisses, granites and granite-pegmatite. From the two areas in which there is a prospect of the occurrence of gold, no sand samples were obtained for reasons already given.

Transport and Labour.

The chief mineral deposits are all within forty miles of the sea-coast; the galena, coal, lignite and petroleum are within thirty miles. Transport in the Protectorate is by camels, of which there are very large numbers, according to one authority nearly a quarter of a million. A burden camel will carry loads up to 300 lbs. weight, will travel from 16 to 20 miles per day, and the cost of transport is one rupee (about 1s. 4d. per camel per day), the camel owner providing his own equipment and rations.

There is plenty of unskilled coolie labour, the direct control of which is best placed in the hands of a Somali overseer. The rate of pay ranges from 8 to 12 annas per man per day, exclusive of rations, and the cost of the latter at the Government rate is about 3½ annas per man per day.

(B.) WATER RESOURCES.

It has been generally considered that the Protectorate is a hot, arid, in parts sandy, in parts rocky expanse in which water supplies are rare and, where existing, mostly of poor quality. While this is to a large extent true of the coastal plain and of the Guban country that extends from the coast to the bottom of the main scarp or to the foothills of the main inland axis east and west of the scarp, it is by no means true of the upland country which lies south of a line drawn through Las Gori and Hais; Wagger, Sheikh and Hargeisa; Boramo and Somadu; in other words, south of the mountains and foothills which separate the country of a maximum elevation—exclusive of individual peaks and ridges—of 2,500 feet, from that of an elevation of 3,000 feet upwards. Moreover, the coastal plain and the Guban nowhere extend—except behind Zyla—for a greater distance than about forty miles from the coast, whereas the country on top of the scarp and main axis extends for more than a hundred miles to the south. During several seasons of the Somali year, abundant rain falls on the high country, almost every tug at some time of the year is a flowing stream, and it is no uncommon sight to see a broad flowing stream in the low-lying country of the Guban many miles from the district in which the rain has fallen. Statistics of rainfall kept at Hargeisa by the Medical Department show that in one month of 1922, at least 25 inches of rain fell at this hill station, and undoubtedly during the north-east monsoon the heights of the Golis, of Wagger, of Boramo and of the escarpment in the east behind Las Gori are daily enveloped in rain-clouds, and, in the rainy seasons, scarcely a day passes without some water falling. The rainwater flows in two main directions, north and south of the Golis scarp and the mountain ridges to the east and west of it, but as the north side is extremely steep and the south side a gradual slope, ravines and torrents which are so common and conspicuous on the former are rare on the latter. On the south side, the streams appear to join together early into a few major channels, and, owing to the surface being uniformly sandy or calcareous, the water very soon disappears out of sight. Even on the north side, owing also to the loose sandy nature of the stream beds, the water of the ravines rarely flows above the surface for any considerable distance, but whereas " durdurs " and permanent springs appear to be uncommon on the south side, they occur in considerable numbers on the north.

In view of the large rainfall and the dryness of the Guban and the coastal plains, the question arises as to what becomes of the water. Including the fault ridges of the Guban, there is a gradual fall in the elevation of the land from the foot of the

* In the sand from the bank of Amud Tug near Boramo, assay returns gave 1 dwt. of silver per ton (see Gold).

scarp from 2,500 feet to sea-level, and this fall is spread over a distance varying from 50 miles in the west to two or three miles in the east. Moreover, there is little doubt that the floor of the Guban is formed of gneiss and is covered with alluvial sand and gravels, and in the east to some extent with limestone, brought down by torrents from the high levels. What really takes place, therefore, particularly on the north side of the scarp and less conspicuously on the south side, is that the water pouring down the slopes of the scarps, ridges and foothills is carried by its own momentum a greater or less distance over the alluvial, and then, owing to the looseness of the latter, sinks out of sight. Having sunk, however, it still flows on out to the sea, for, under the sand and gravel, there is in each tug a more or less well-marked channel in the gneissic floor, and a gradual slope everywhere to the coast. Conserved in places, or obstructed in its course, it forms permanent springs and the water issuing from these again sinks and continues on as before.

It follows, therefore, that there must be annually an enormous amount of water of excellent quality that has fallen on the uplands flowing unseen and untapped under the alluvium of the arid Guban to the sea. It is, of course, not flowing everywhere, but in well-defined old stream channels that were originally exposed at the surface, but which in the course of time have been covered with sand and gravel.

That this is the case is indicated by a number of facts: (*a*) The large number of "durdurs" that occur between, say, Mandera or Gan Libah and El dur Elan to the east of Las Dureh; (*b*) the large number of permanent fresh-water wells near and at the bottom of the scarp and ridges; (*c*) in many tugs the Somalis have but to sink a hole in the sand to various depths to obtain water which keeps the same level for an indefinite time; (*d*) even within a few yards of the sea-coast in many places, fresh-water wells occur or can be made by digging in the tug beds; (*e*) the occurrence half-way across the Guban or coastal plain, and even within a few miles of the coast, of springs from which issue many thousands of gallons of water per day.

Durdurs of excellent water occur, for example, at Durdur Ad north of Boramo, at Hennweina near Gan Libah, at Lower Sheikh, on the east side of Wagger Range, in Ashararet Range, and even near Kaufli Range south of Ankor. Permanent wells occur at Gibele, Hargeisa, Argan, Mandera, Hul Kaboba and many other places. Near the coast, water is obtained in tugs at Wagderia, Hashau, Raguda, Ankor, Karam. In Bihendula Range, near the Rest House, half-way across the Guban, is a spring from which probably 100,000 gallons a day issue, flow away down the tug for about a quarter of mile, and disappear beneath the sand. At Biyogora, to the south-east of Berbera, large springs issue from the junction of the limestones and sandstones, and form a stream which largely disappears after flowing a short distance. At Dubar, about eight miles south of Berbera, is a series of springs which give a flow of about one million gallons a day, and from which the water is gravitated by means of a pipe-line to supply the needs of the town.

On the south side of the high level ridges, a similar condition of affairs appears to exist, but not in the same degree. The writer had no opportunity of examining this part of the country except between Sheikh and Burao, but from information obtained, there would appear to be a considerable number of permanent wells, some, as at El Afweina, Gud Anod, El Der, Erigavo, Kirrit, etc., with water exposed at the surface, others, as at Burao, with water at a varying depth in a tug. Durdurs, however, are rare and the quality of the water except in Burao is not so good as on the north side. The streamlets on the top of the scarp tend to join together to form a few large water-courses. In the Sheikh-Burao area, for instance, most of the streamlets join the tug which flows from near Sheikh through Burao and ultimately becomes the Tug Der some miles below Burao. Moreover, it is only immediately after heavy rain on the Golis and Wagger Range that water is actually seen in the tug. It sinks out of sight very quickly and yet is always present under the surface in old water channels which may or may not correspond with the course of the present tug. At Burao water is always obtainable in wells on the side of the tug at a depth of seventy feet even in the dry season, and that there is a large underground water channel extending for many miles below Burao is shown by the luxuriance of the grass over a clearly defined stretch of country as far south as Kirrit.

It is clear that the conception of the Protectorate as a waterless expanse is due not to the lack of rainfall and the absence of water supplies, but to the fact that they are to a large extent concealed, that the resources are quite undeveloped, and that no attempts have been so far made even by the natives to conserve the rainfall. In the interests of the natives, of their flocks and herds, and of the country, steps should be taken to improve the water supply. The numbers and quality of the live stock on which the Somalis at present live, and which form the chief trade asset to the country, would be greatly increased if more plentiful supplies of water, and of water of a better

quality than that now generally used, were obtainable. Much of the wealth of the Somalis comes from the sale of ghee, which is produced largely from the milk of their cattle, and it is well known that, at present, they have to drive their flocks long distances to known wells, surface pools and durdurs, and that in some years lack of water and feed during the dry season causes considerable mortality from starvation, while in all years this same lack reduces all their animals to poor condition. The natives have no idea how to sink a well, exercise no care to prevent contamination of the water by manure or to prevent evaporation, and, indeed, even wash in, bathe in, and drink the water that the stock have been driven through. The health, too, of a considerable part of the population would be considerably benefited by provision of cleaner water, and it is probable that, by development of existing supplies, something can be done to utilise the areas of agricultural land and to get better returns from the large tracts of pastoral land which undoubtedly exist in the Protectorate.

While the methods to be adopted to this end depend on the geological and other conditions in each area, and should be decided on only after an examination of these conditions, it is nevertheless possible to set out a few in general terms:—

(1) Tapping the considerable bodies of water which at present flow underground probably along old stream channels from the hilly country to the sea. This would require investigation of the course of these channels, but when they are found, if spots are selected with care and skill, good water in large amount should be obtainable in wells of varying depth.

(2) Forming permanent protected wells at the numerous durdurs in the tugs on both sides of the main axis.

(3) Forming permanent wells in the numerous tugs in which water is now got by Somalis by sinking holes in the sand. These holes are now constantly being fouled and periodically silted up, but by the use of perforated and screened piping in wells put down to considerable depths, silting could be to a great extent prevented and the water could be protected from contamination and evaporation.

(4) In places where settlements exist or could be established, and where the rainfall is considerable, reservoirs or dams could be constructed, as far as practicable with a cover to prevent evaporation.

(5) Opening out, cleaning and protecting existing wells which are used by the natives.

It has been suggested by some that several of the larger springs could be used for irrigation purposes, but as the character of the alluvium on the coastal and inland plain cannot, except perhaps in one or two areas, be described as promising, as it is only on the coastal and inland plain that a sufficient hydrostatic head can be obtained to allow of the flow of sufficient quantities of water, and as, in the hot season, the south-west monsoon and the accompanying dust destroy practically all except indigenous vegetation,* irrigation on any considerable scale appears to be impracticable.

During the operations against the Mullah, it was stated by Major Lotbinière, R.E., that the structure of that part of the country lying to the south of the Golis Range was favourable for the occurrence of artesian water, and in at least four places, viz., at Babur, Derkeinleh, Erkadalanleh and Kirrit, boreholes were sunk to a depth of 380 feet and more with the object of obtaining an artesian supply.

Nowhere was such a supply met with. On the other hand, in no single instance was the boring continued until bedrock was reached. There is no doubt that along the summit and southern slopes of the main watershed, there is sufficient rainfall and, to some extent at any rate, a suitable intake to provide an artesian supply, but whether the sequence of beds and the geological structure of the country are such as to render possible the existence of an artesian basin are questions which can only be settled by an examination of the country. Owing to its distance from the coast and the amount of time required for such an examination, this was not practicable. The little evidence, however, obtained in a trip from Sheikh southwards to Kirrit along the motor track appeared rather unfavourable for the existence of a basin. In view of the great importance of a supply of artesian or even of sub-artesian water, especially in the country west of Burao, as bedrock was not reached in any of the bores put down, and as nothing is known of the nature of the strata, it seems advisable that a geological report on this part of the country should be obtained.

Sub-artesian water, of course, has been drawn for many years from the tug at Burao itself.

* On the Guban.

(C) SOILS.

The possibilities of parts of the high level country as regards agriculture were first impressed on the writer at Boramo, a police-post west of Hargeisa, in Western Somaliland, and subsequent travelling has served to bring about the conviction that with care and patience considerable areas can be used for the cultivation of crops with profit to the owner and ultimately to the Protectorate. At the request of the Governor, a short report was prepared on the soil of the Boramo plain, and, as the statements contained in it apply to a great extent to other areas, a summary of the chief of them will give a general idea of the characters on which a favourable impression was based.

Much of the plain supports all the year round a luxuriant vegetation in some parts and abundant grass in others. The rocks of the hilly country surrounding the plain comprise granitic and hornblendic gneisses with intrusions of pink microcline granite, prominent bars and hills of epidiorite, and Jurassic limestones with intercalated clayey and shaly bands. Though no records exist of the actual rainfall, there is no doubt whatever that the surrounding ridges and the plain are subjected during several seasons of the year to heavy falls of rain. The water running down the slopes has, in the course of ages, carried down detritus into small short nullahs, which, deep at their beginning on the high ground, have broadened out and precipitated their solid content to form an alluvial plain. As it is an established fact in other countries with a tropical and semi-tropical climate, that even residual soils of basic hornblendic rocks will, for a time, if the rainfall is sufficient, produce excellent crops of cereals—if varieties suitable to the climate are sown—and luxuriant grass, this alluvium, composed of the thoroughly mixed constituents of potash and phosphorus-bearing acid and basic rocks, clays and limestones, together with vegetable matter, clearly contains many of the essentials of a good soil. Moreover, examination of holes and trenches in the plain and inspection of the banks of the lower portions of the nullahs show that the depth of the alluvium is at least three feet and ranges up to ten feet. Cursory examination, also, of the consistency of the soil tends to show that it is neither too sandy nor too clayey, and this is supported by the fact that the water does not at once disappear beneath the surface as on the coastal alluvium, and yet does not remain for considerable periods in shallow pans, that there is always, in the holes and trenches, a fairly thick deposit of silt, and that the grass and vegetation remain green for long periods after a rainy season.

That the soil will produce excellent crops of jowari has already been proved by the Abyssinians. On the Halissa plain to the south of Boramo, there are many small agricultural plots, surrounded by zeribas, on which this cereal is grown, to be ultimately, in part at least, sold to the Somali, and the soil of the Halissa plain, though produced from similar rocks, is less completely alluvial than that of Boramo.

Though no search could, owing to the nature of the work in hand, be made for them, other areas were encountered more promising than the Boramo plain. Round Gibele and south of the motor-track, from Hargeisa towards Boramo, is a large plain many miles in extent with a soil produced from rocks similar to those at Boramo, watered by a periodic rainfall which, though at present of unknown amount, is nevertheless considerably over ten inches per annum, of considerable depth, and, so far as can be judged without chemical and mechanical analysis and trial, eminently suitable for raising crops. At the present time, part of the plain is let in small plots to Somalis, and on these plots, even with very rudimentary methods of tillage and without the use of a fertiliser, good crops of jowari are grown year after year.

At Hargeisa, and between Hargeisa and Haleya, grass and vegetation flourish on a plain of considerable size, and, without appreciable effort abundant crops of jowari are grown by the natives on plots and by tillage similar to those at Gibele.

Parts of the plateau south of the Golis Range are also conspicuous for grass and vegetation, and considerable areas of cultivable land occur there or could, with little clearing, be brought into existence. This plateau is exceptionally well watered and sheltered more or less from the south-west monsoon.

While these are the areas met with in the course of the Mineral Survey which offer most promise, there is little doubt that others exist of equal or greater extent and of equal promise. The Arori plain, for instance, between Hargeisa and Burao, of many square miles in extent, appears, from reports of various officers, to be eminently suitable either for grazing purposes or for agriculture, provided a water supply for stock and domestic use could be ensured.

As regards the particular plants for which the soils are suitable, there is reason to believe that wheat and similar cereals can be successfully grown on several of the plains, and as excellent coffee is produced in Abyssinia not very far from Hargeisa, there is a prospect that this plant could be cultivated with profit in some localities. It has

also been suggested that tobacco could be grown to advantage, especially on the plateau below the Golis scarp.

From the standpoint of agriculture, however, in addition to the nature of the soil, there are other considerations of importance so far as this Protectorate is concerned, to which only a brief reference can be made. These are:—

1. Protection.
2. Character of the native.
3. Water supply.
4. Rainfall.
5. Communications.

1. Protection.—In the initial stages of the establishment of agriculture, it would probably be necessary for some measure of protection to be ensured for each settlement. This is a matter, however, to be dealt with by the Administration, and beyond the scope of this report.

2. Character of the native.—In the development of agriculture, particularly in a Protectorate with a native population of 280,000, it is obvious that efforts should be directed to inducing the native to take up the work himself both in his own interests and in those of the Protectorate. It is and will continue to be for various reasons undesirable to introduce white immigrants on any but the smallest scale. On the other hand, the laziness of the Somali, his lack of initiative and his nomadic habits render him at present indifferent to agricultural work, and it is difficult to see how, without special inducement, he can in any numbers be brought to live in fixed settlements and to adopt a fixed mode of life. As he is, however, intelligent and avaricious, it is probable that the required interest in the work could be aroused in time by an appeal to his cupidity through the force of example. Already a fair number of natives cultivate by crude methods small plots of ground to grow jowari, and if it could be shown them by actual example that, whereas, by adopting his own methods he obtains his usual small returns, by adopting modern methods his neighbour obtains a return many times greater, there is little doubt that in time he will be prepared to abandon his own in favour of his neighbour's methods. It will be essential, though, that the example be set him.

3. Water Supply.—The areas mentioned above, except the Arori plain, all have permanent water at no inconvenient distance, either permanent wells or durdurs in the sandy tugs. For settlements, however, it would be necessary to have a larger reserve supply, and this could with no great difficulty be ensured by the provision of dams or reservoirs covered in to prevent contamination and evaporation. The requirements of each area could be satisfied according to local conditions.

4. Rainfall.—In many areas holding out a possibility of agricultural settlement it is a matter of importance to know (*a*) the average rainfall for the year, (*b*) the months in which rain falls and the amount for each month, (*c*) the amount that falls at any one time. A rain-gauge has been set up by the Medical Department at Burao and Hargeisa, of the hill stations, but there was none at Gibele or at Boramo. In view of possible future development, a gauge should be set up at each of these two posts and an accurate record kept of the registrations.

5. Communications.—A motor track connects Berbera on the coast with Burao, Burao with Hargeisa, Hargeisa with Gibele. From Gibele the track runs to within a few miles from Boramo. Again, there is a well-known camel track from Boramo to Hargeisa, and from Hargeisa through Hamala Tomalod on the Berbera plain to Berbera. Moreover, a route has been surveyed for a railway line to connect Jigjiga in Abyssinia with Hargeisa and Hargeisa with Berbera. In the event, therefore, of the establishment of an agricultural industry in the Hargeisa-Gibele district or between Burao and Boramo, there would be no difficulty in regard to transport.

IV.—CONCLUSIONS AND RECOMMENDATIONS.

In a tour of one year only, even though the geological work was pursued seven days a week throughout the tour and a distance of over two thousand miles was covered, owing to the difficult character of the tracks, the extreme heat, the necessity for periodical changes in transport-camels and guides, the extent to which travelling was influenced by water supply, the difficulty of arranging for animal and men's rations while on the march, and the necessity of conducting all official correspondence, paying wages and keeping accounts up-to-date from a camp which was moved from day to day—for these reasons, it was manifestly impossible to do more than find and briefly examine the mineral occurrences already reported chiefly by Somalis, to

investigate briefly the country in the vicinity of the traverse with the object of discovering additional minerals, and to form a reasonably accurate opinion as to what areas of country held out some promise of the presence of minerals of economic value.

Minerals of economic value and areas of some promise having been found, it would appear to be the proper course to have the chief occurrences examined in detail and the promising areas thoroughly prospected.

The existence of a coal seam of appreciable thickness and similar to that now being used on the railways and steamboats of Nigeria has been proved in the region south of Ankor, and in the interests of the Protectorate and of a general knowledge of the coal resources of the Empire, a careful examination should be made of this region with the object of discovering the same or another seam in other tugs and of proving whether or not other seams occur below the one exposed but in the same locality. The exposed seam should itself be opened out sufficiently to enable typical examples along its whole thickness to be obtained so that accurate data as to its value and the best methods of treating it may be got from analyses and trials by the Imperial Institute.

The results of the examination of the lignite from Khal Der have shown that they are at least equal to those now being worked on a commercial scale at Breunsdorf, in Germany, and to the undeveloped deposits from Okpanam, in Nigeria. Therefore, a thorough search should be made of the outcrops of the series containing them, and, if possible, an attempt should be made by means of a boring plant to prove whether other seams exist at somewhat lower levels. The seams at present known are too thin for exploitation, but, if further search should prove the existence of considerable deposits of lignite, sufficiently large samples should be sent to the Imperial Institute to enable pressure-briquetting tests to be carried out on the lines adopted for Nigerian lignite. The locality is close to Berbera, and transport would present no difficulty. Though it may not be profitable to work the lignite by itself, the material may be worthy of attention in the event of the coal at Hedhed being exploited.

The district south-east of Las Gori, formed of an old series of slates, should be thoroughly examined. Both galena and cinnabar having, apparently, been found in Italian territory close to the border, and galena having already been found on the British side, there is a distinct chance of the discovery of workable lead ore veins and of cinnabar on the latter. Moreover, though the amount of silver present in the galena samples so far assayed is too small to be of value, in view of the occurrence at Kul of the granular or imperfectly crystalline variety which is held to contain a larger amount of silver than the normal variety, deposits of the mineral may be found which are of value for their silver content. Further, as quartz reefs are numerous in the district, and as many of them are ferruginous and of the type in which gold may be expected, the district should be prospected also for gold, especially in view of the suggestions and attempts to prove that the gold-mining districts known to the ancients as Sasu and Punt are identical with it.

The country to the west of Boramo, in which, according to the late Colonel Ashby, gold occurs in the tugs, and in which he had numerous coolies at work on a mineral occurrence, certainly calls for a geological examination.

The northern slopes of the Mirsa Plateau should be further prospected for mica, beryl and garnet. The extent of the deposits of each of these three minerals should be proved as far as possible, and representative samples of mica from depths at which it is unaffected by weathering should be sent to the brokers for an estimate of value, and, if they are satisfactory, with a view to exploitation of the deposits by the firms* reporting on the samples.

For obvious reasons, some inquiry should be made into the basis for the assertions of the occurrence of diamonds or possible diamondiferous country in the south-eastern part of the Protectorate.

The present state of ignorance with regard to the occurrence of guano on Mait Island should be cleared up. The deposit may be only of local value, but, in any event, it is clear from the analysis that it is of use as a fertiliser, and, if only in view of the agricultural possibilities of the Protectorate, the extent and thickness and the chemical nature of the material as a whole should be known and recorded. If, as is the case on some of the Seychelles Islands, lime phosphate is present in considerable quantity, the deposit may be almost immediately productive of revenue to the Protectorate.

Finally, an investigation should be made of the unexplored tract of country between Hargeisa and Bulhar, especially in view of rumours of the existence in it of exceptionally good mica.

* In default of other private enterprise. One firm has already expressed an interest in the deposits.

Already there have been several requests to the Somaliland Administration from prospectors for permission to examine tracts of country for particular minerals, and it is probable that, owing to the interest aroused by the recent geological survey, by the reports on the petroleum at Dagaha Shabell, and the exhibits at the Empire Exhibition, further requests will be made. Under the unusually difficult conditions of travel and existence in the Protectorate, it is clearly more advantageous to all the interests concerned that these investigations should be carried out by a Geologist with experience of these or similar conditions than that reliance should be placed on the results achieved by more or less uninstructed and inexperienced prospectors and syndicates. By all means prospectors should be allowed to search for minerals, but subject to supervision, and on the understanding that an inability on their part to find anything of value does not necessarily prove that it does not exist. This inability and the collection of poor samples may be merely a measure of their ignorance. A large amount of mica, for instance, was at one time collected from the northern slopes of the Mirsa Plateau, and was regarded as typical of the chief occurrences of the mineral in the area. It was worthless, yet excellent samples have been obtained by the writer and others from the same place, and inquiries showed that the former samples had been picked up from the surface where they had been exposed to the weather for many years and no attempt had been made to examine the material below the surface. The prospects of development of the Protectorate should not, at this stage at least, be wholly at the mercy of prospectors and syndicates. What is particularly necessary is reliable information which can be used by enterprise as a basis and a guide, and reports on the lines set out above will provide this information and prevent, on the one hand, any "wild cat" ventures, and, on the other, undeserved depreciation of any occurrence.

The investigation and development of the mineral resources of the country will be further greatly facilitated by geological knowledge and experience devoted at the same time for the necessary period (*a*) to assisting those interested by determining minerals, proving mineral occurrences, affording advice on the value, method of prospecting and possibly of exploiting deposits, and on the conditions of travel, water supply, and location of promising areas.

(*b*) Establishing small reference collections of minerals for the guidance of administrative and other officers who travel considerably in the various districts, and of others engaged in a search for minerals.

(*c*) To increasing the interest of the Somali himself in finding minerals. Most of the minerals formerly obtained in the Protectorate were found by Somalis, and it has frequently been proved that their intelligence and nomadic habits well fit them for prospecting. At present they are averse from trying to find minerals or from making known any discovery, owing to their alleged unfortunate experience in regard to the finding of the Dagaha Shabell oil, for which apparently they received no reward. There is no doubt, however, that, if they are assured of fair treatment and a reward (amounting only to a few rupees), not only do they become fairly zealous searchers, but they will willingly disclose the information they have. With reference, for instance, to the coal south of Ankor, they assert that they know of several other outcrops besides the one seen by the writer, but, in the circumstances then existing, it was impossible for the reason given above, to obtain details of the localities.

(*d*) To assisting the Administration by preventing exaggeration of the value or false reports of occurrencies, by advice, when it may be desired, on matters relating to prospecting, mining regulations, water supplies and minerals generally. Should, for example, the oilfield at Dagaha Shabell be exploited or even thoroughly tested, questions will arise on which expert advice will certainly be necessary, and this should be obtainable with as little delay as possible.

(*e*) By preserving an accurate record of all mineral occurrences, results of their analyses and their current values and uses, by giving them the necessary publicity and by ensuring for them a thorough practical test.


SKETCH MAP OF
BRITISH SOMALILAND
SHOWING
ROUTE FOLLOWED, LOCATION OF MINERAL OCCURRENCES
AND AREAS SHOWING SOME PROMISE FOR PROSPECTING.
BY R. A. FARQUHARSON, M.A. (Oxon), M.Sc., F.G.S.
Scale, 1:1,000,000 = 16 miles to 1·014 Inches
English Miles
Heights in English Feet
REFERENCE
Route shown.................thus
Mineral occurrences..........
Areas of some promise........
Boundary of the British Somaliland Protectorate
Topography based largely on the War Office Map, October, 1922, with some features accentuated and including some which work in the field has shown to be more or less inaccurate, and which will be amended in subsequent issues.
EXPLANATION
Co = Coal
Li = Lignite
Pe = Petroleum
Pb = Galena
Mi = Mica
Be = Beryl
= Garnet
Ba = Barite
Gy = Gypsum & Celestite
Mo = Molybdenite
Ma = Marble
Sa = Salt
Gu = Guano
Au = Gold
GULF OF ADEN
GULF OF TAJURA
FRENCH SOMALILAND
ITALIAN SOMALILAND
Tajura
JIBUTI
Zeila
Bulhar
BERBERA
Karam
Ankor
Hais
Las Khorai
Hargeisa
Burao
Jigjiga
Hudin
Bohotle
Milmil
HAUD
Longitude East of Greenwich
Stanford's Geographical Establishment, London.